UNIVERSITAT POLITÈCNICA DE CATALUNYA
BARCELONATECH
Escola d'Enginyeria de Barcelona Est

TREBALL FI DE GRAU

Grau en Enginyeria de l'Energia

DISSENY D'UN MINI GENERADOR EÒLIC D'EIX VERTICAL I LA SEVA APLICACIÓ EN VIES INTERURBANES

Volum 4: Annexos

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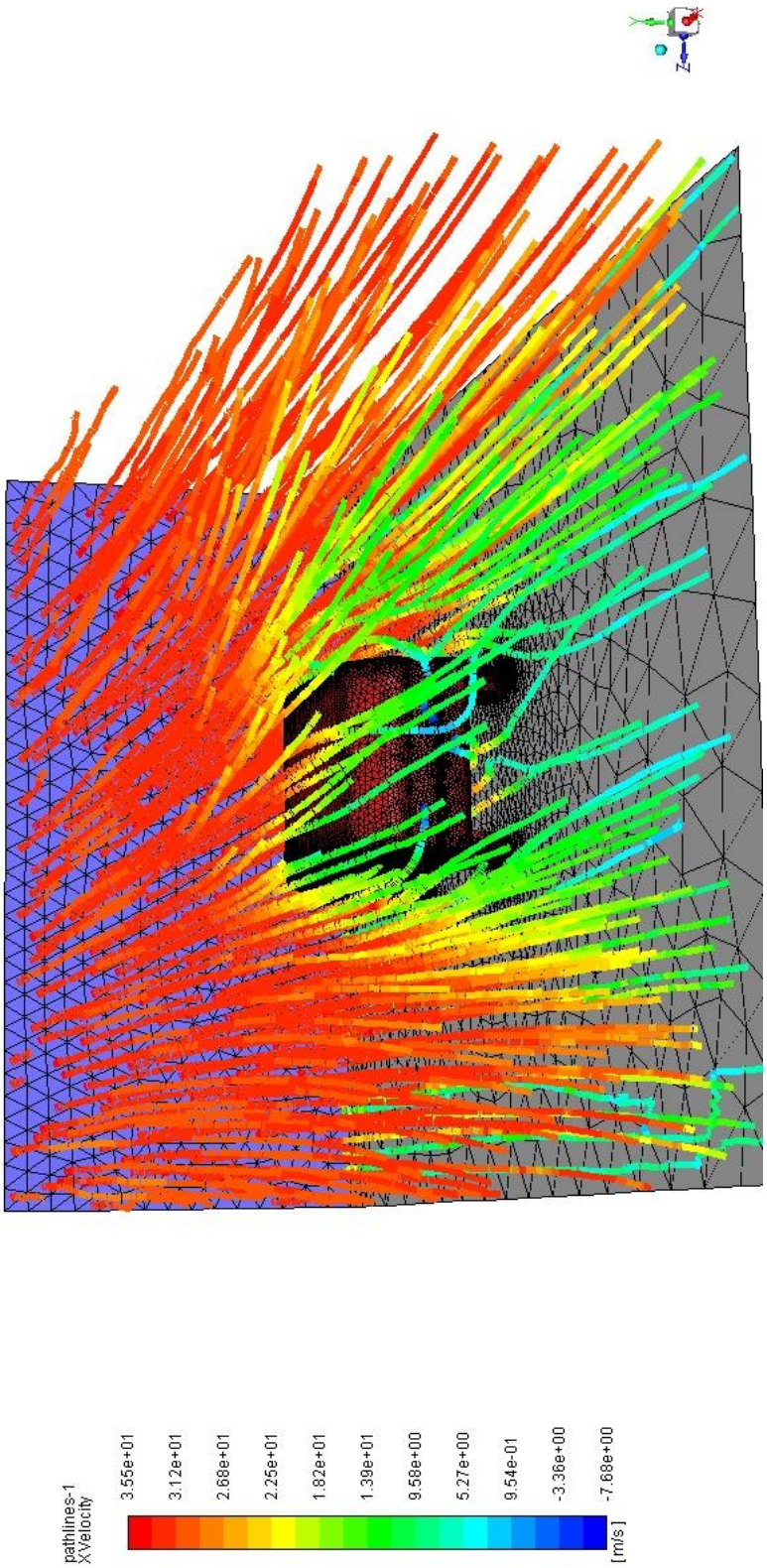
Resum

Aquest document està format per informació externa la qual ha sigut utilitzada durant la realització d'aquest treball i informació addicional obtinguda durant la realització del projecte la qual ajuda a una millor comprensió d'aquest.

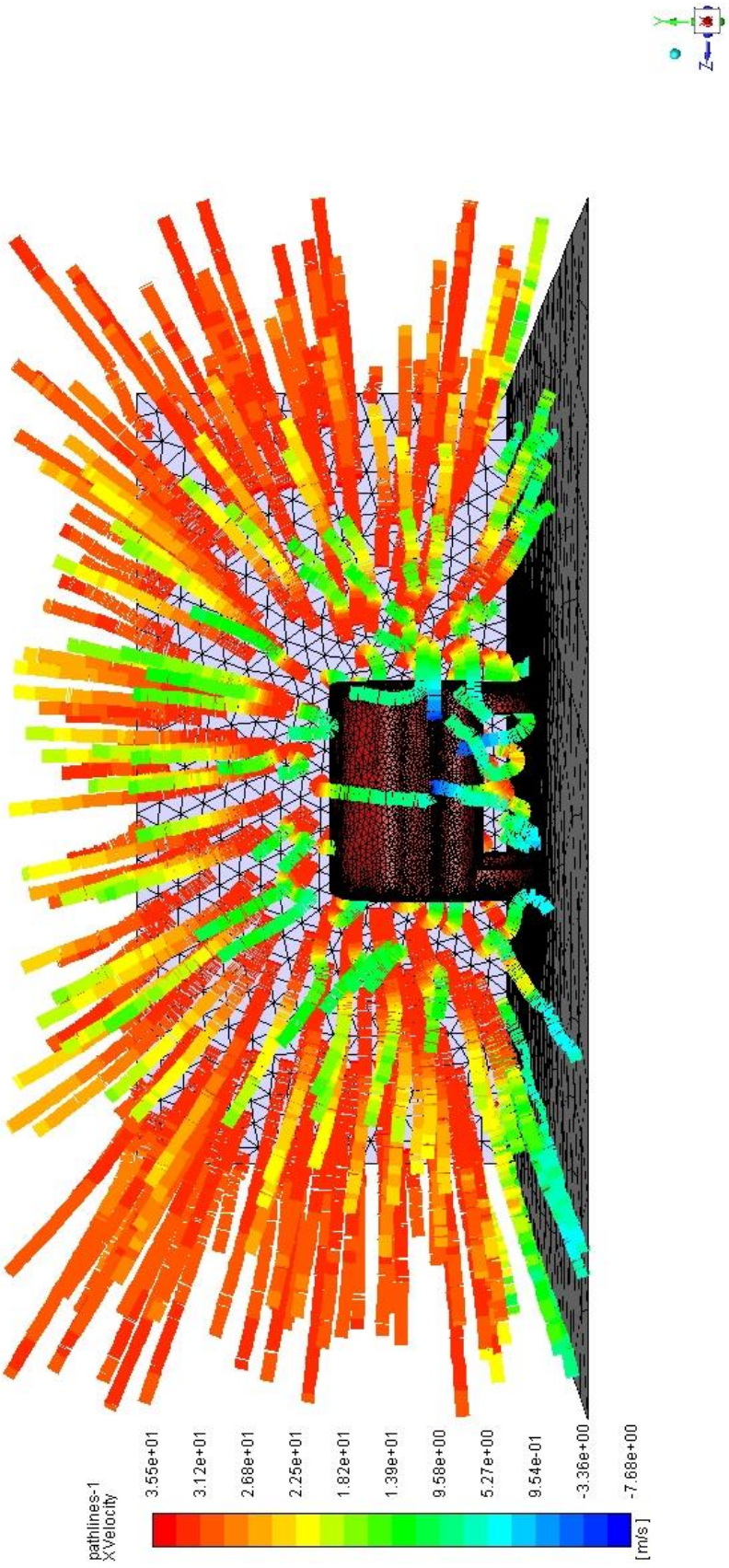
Aquest document està format per les diferents taules utilitzades durant el projecte, imatges addicionals obtingudes de la simulació de la mecànica de fluids i imatges extres dels models i escenaris, el programa informàtic utilitzat per al disseny de l'aerogenerador i els diferents informes obtinguts durant la realització del projecte.

ÍNDEX D'ANNEXOS

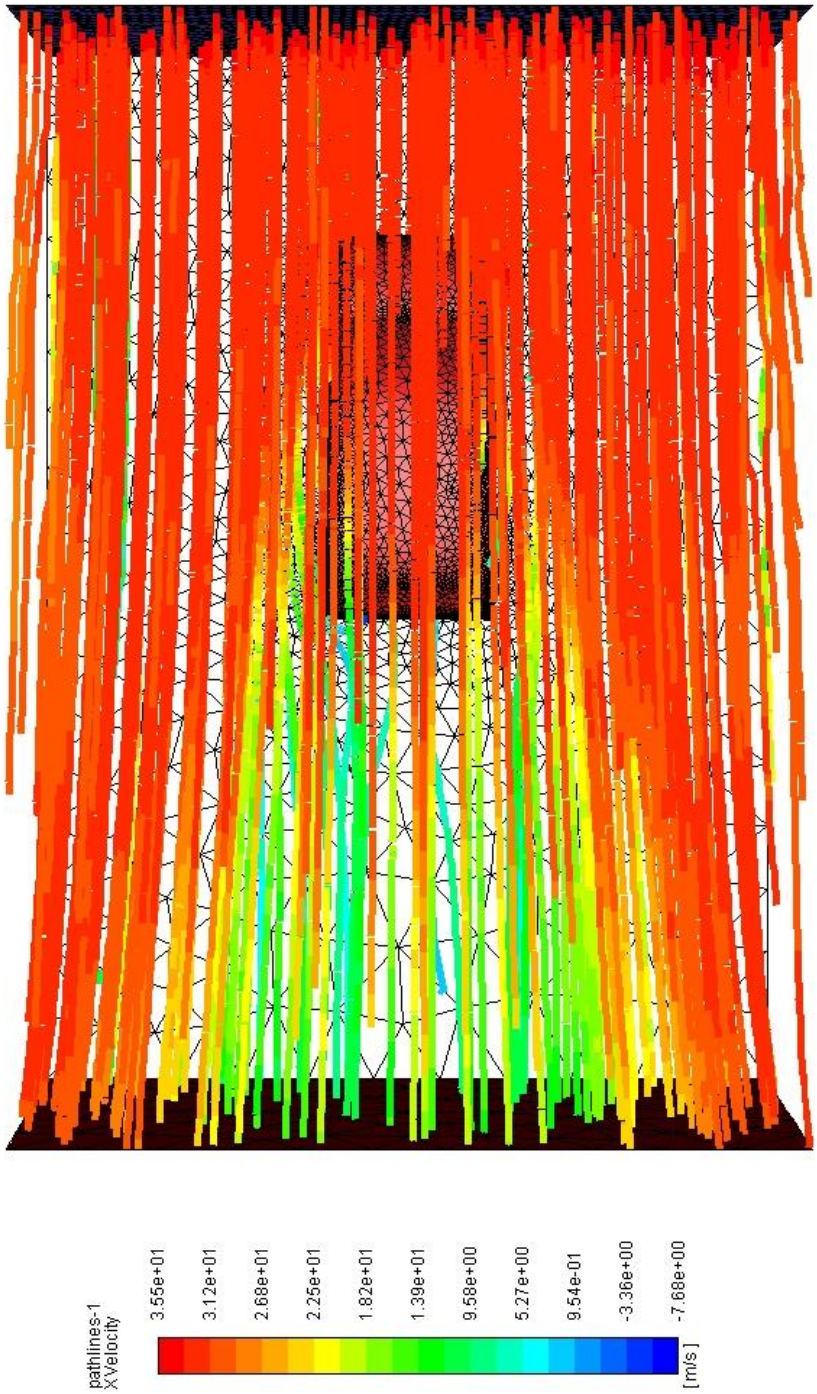
Annex A



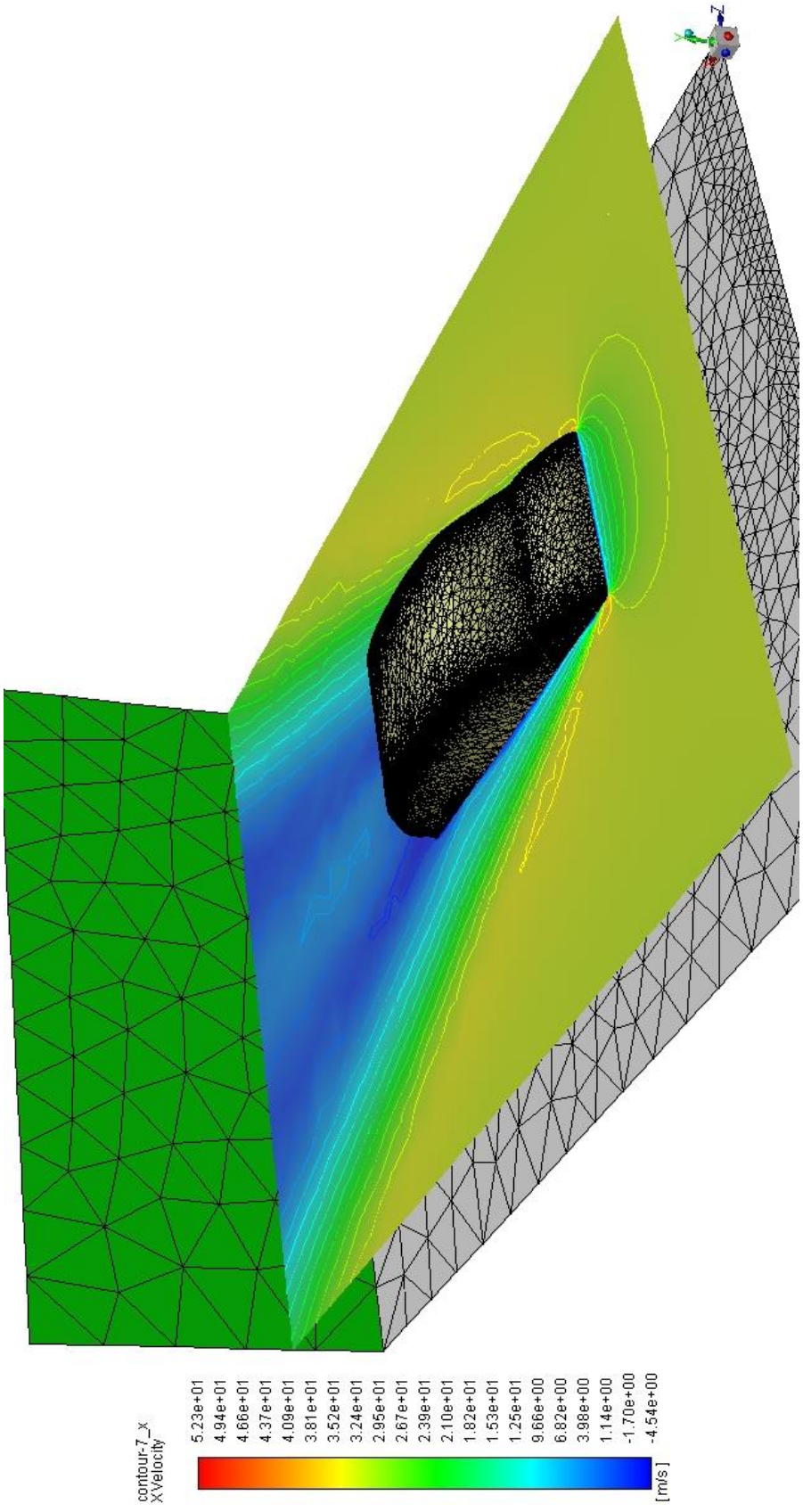
il·lustració 1: Perspectiva posterior de les trajectòries de velocitat (Font: Pròpia)



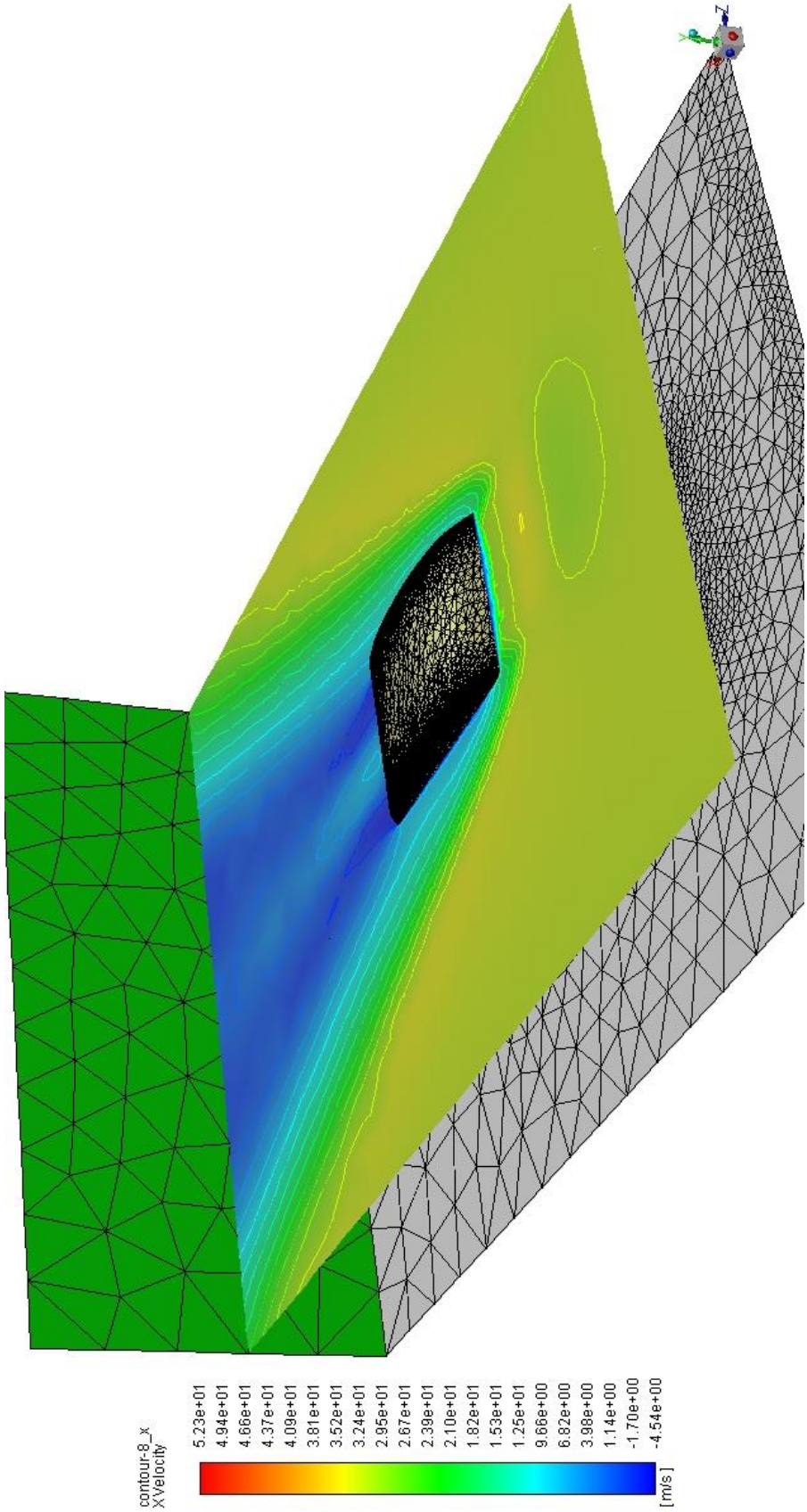
il·lustració 2: Vista posterior de les trajectòries de velocitat (Font: Pròpia)



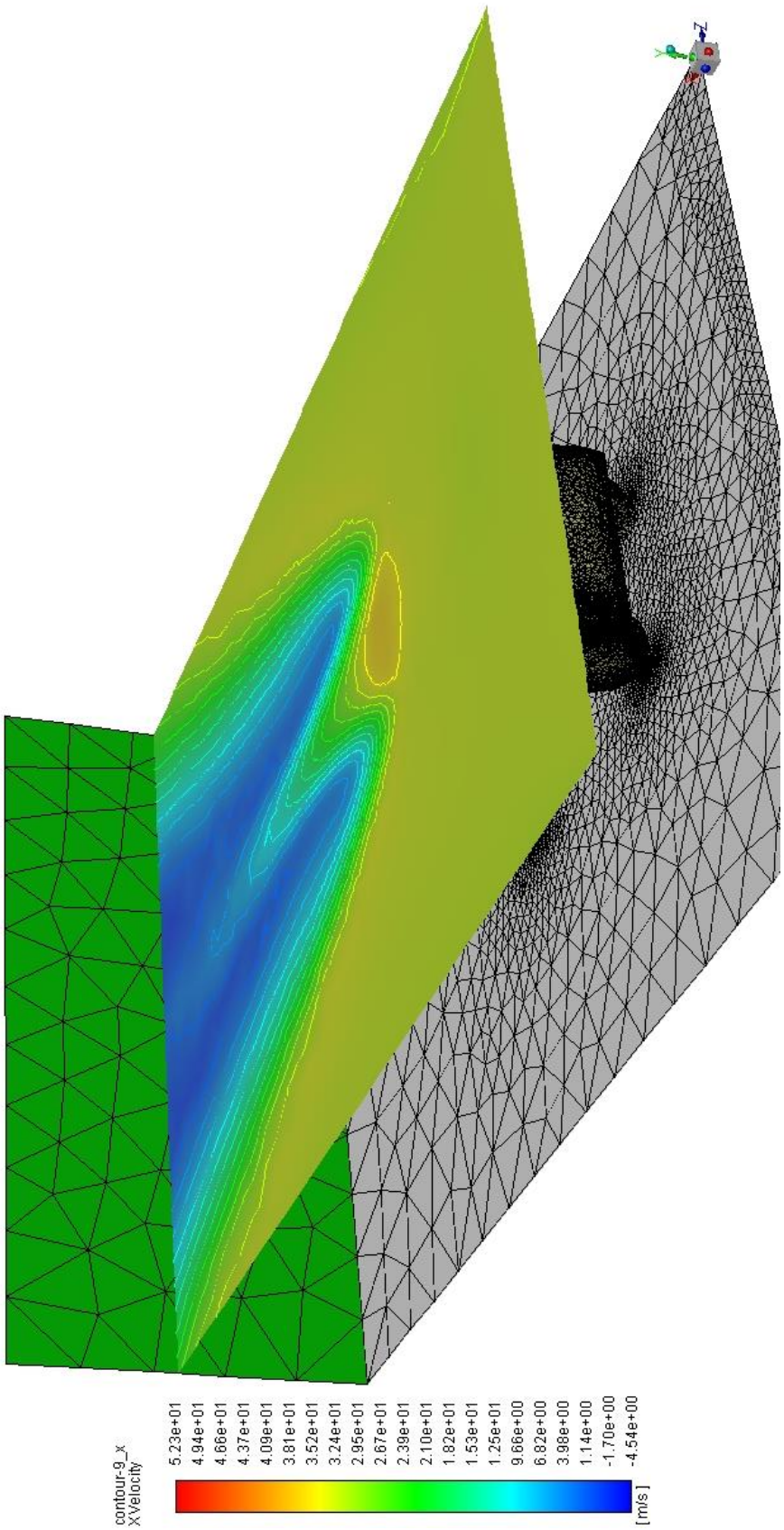
il·lustració 3: Perspectiva zenital de les trajectòries de velocitat (Font: Pròpia)



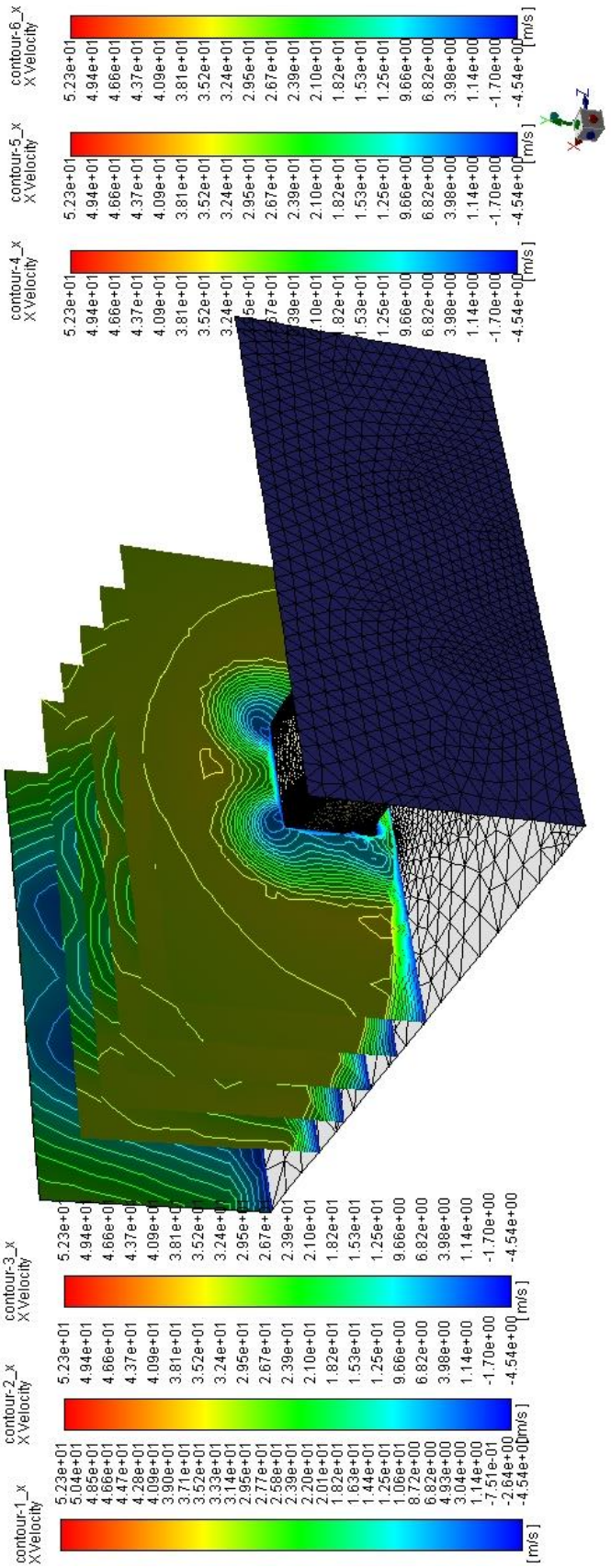
il·lustració 4: Isomètrica del contorn de velocitat a 1 m d'alçada (Font: Pròpia)



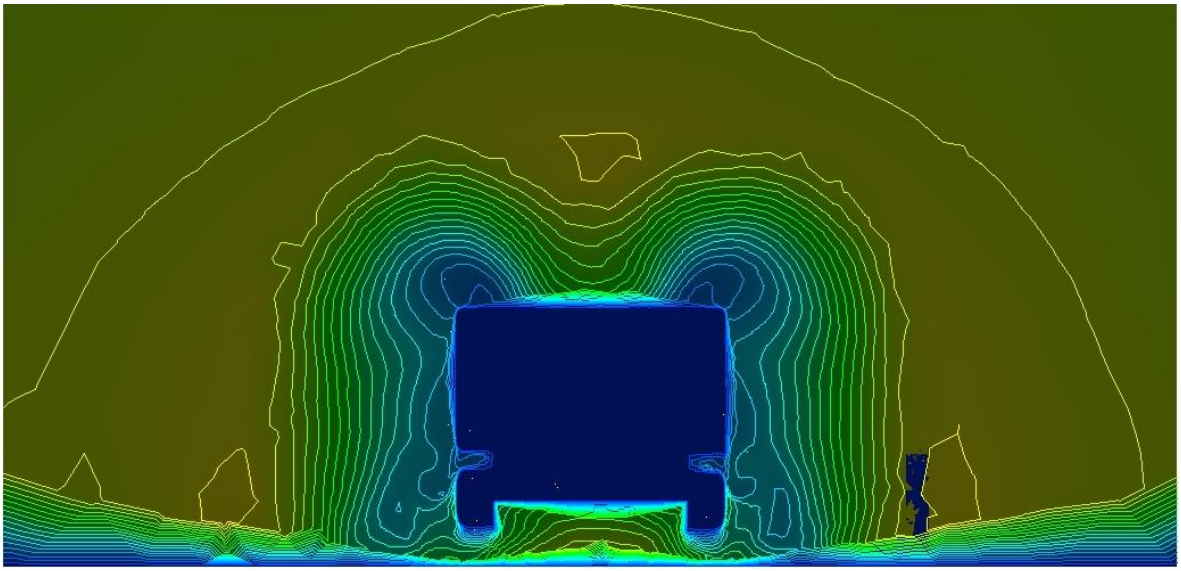
il·lustració 5: Isomètrica del contorn de velocitat a 1,5 m d'alçada (Font: Pròpia)



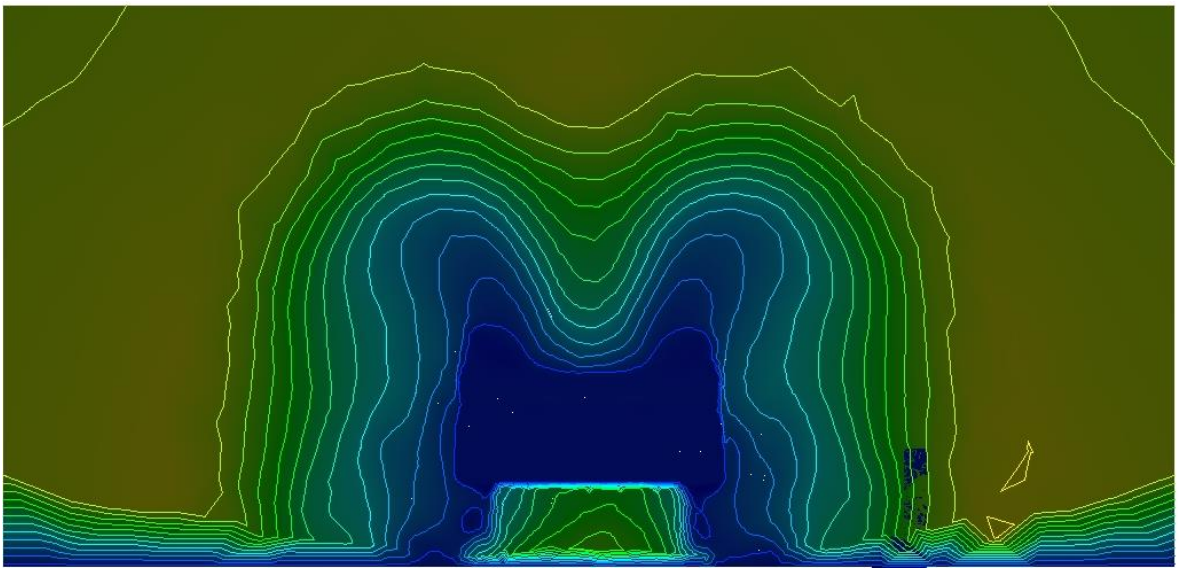
il·lustració 6: Isomètrica del contorn de velocitat a 2 m d'alçada (Font: Pròpia)



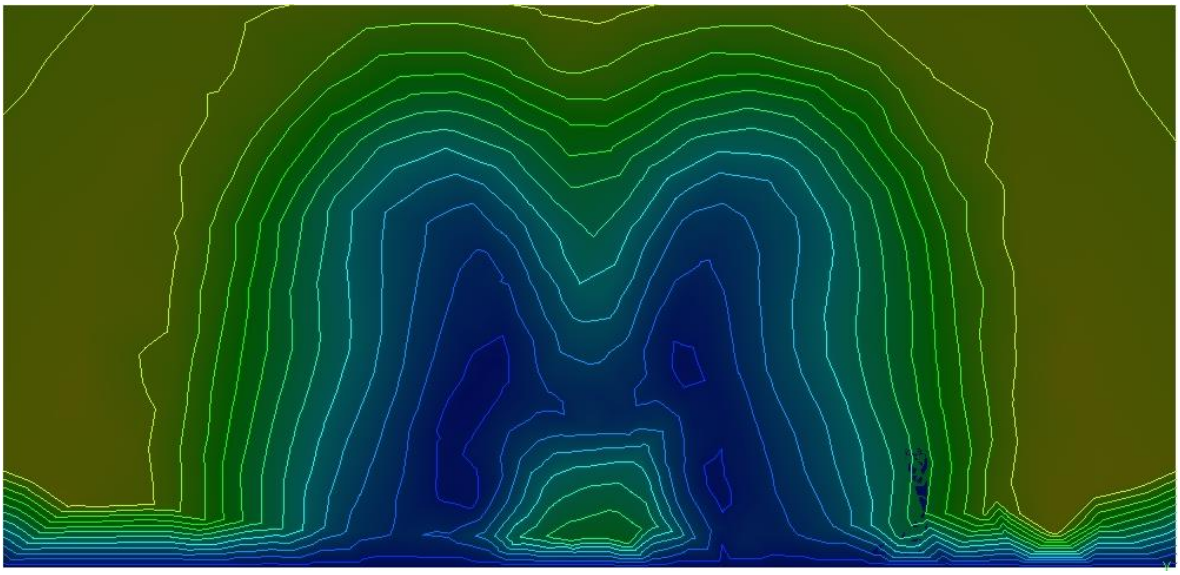
il·lustració 7: Isomètrica dels contorns de velocitat verticals 1, 2, 3, 4, 5 i 6 (Font: Pròpia)



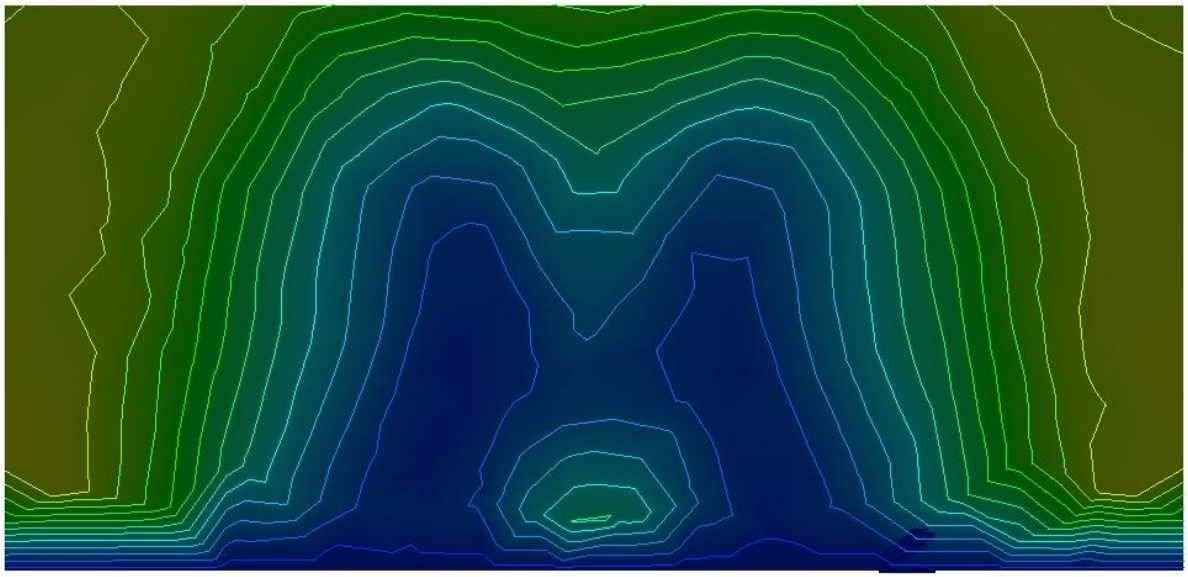
il·lustració 8: Vista del contorn de velocitat vertical 1 (Font: Pròpia)



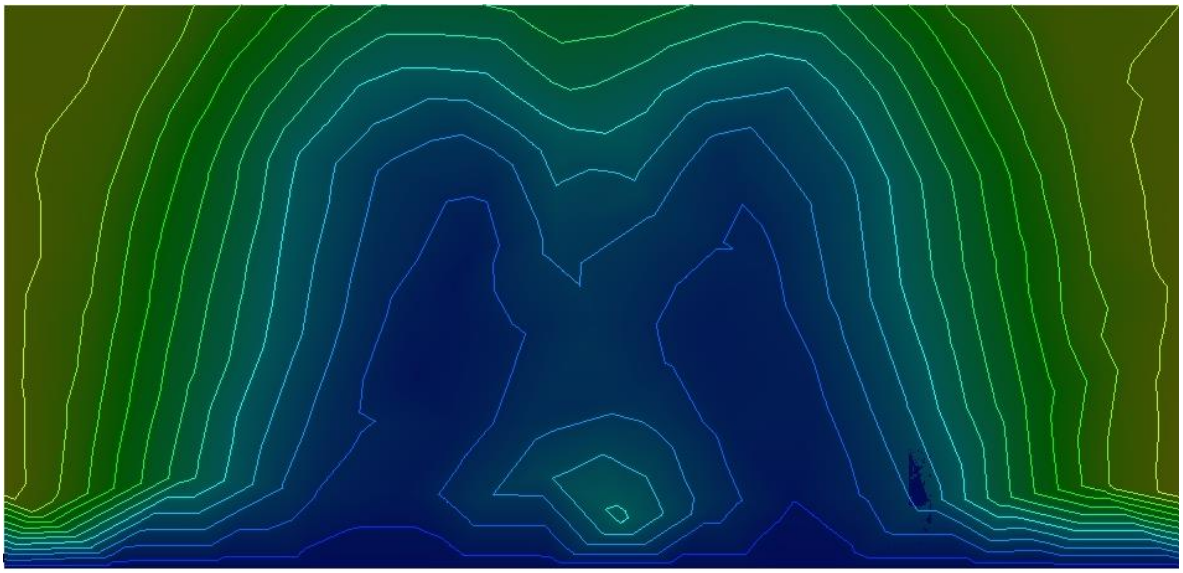
il·lustració 9: Vista del contorn de velocitat vertical 2 (Font: Pròpia)



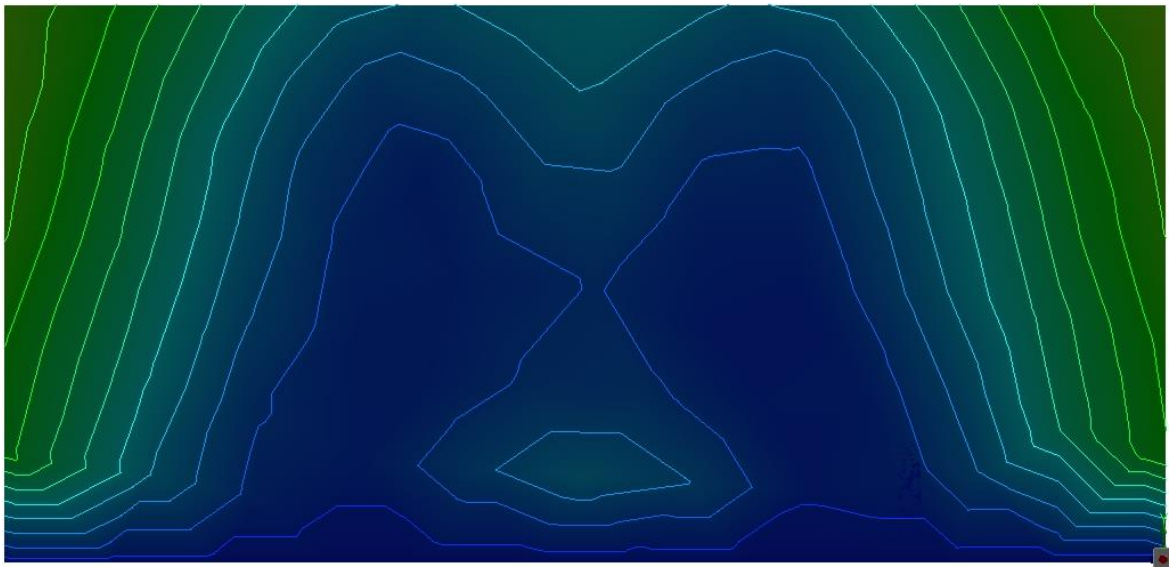
il·lustració 10: Vista del contorn de velocitat vertical 3 (Font: Pròpia)



il·lustració 11: Vista del contorn de velocitat vertical 4 (Font: Pròpia)



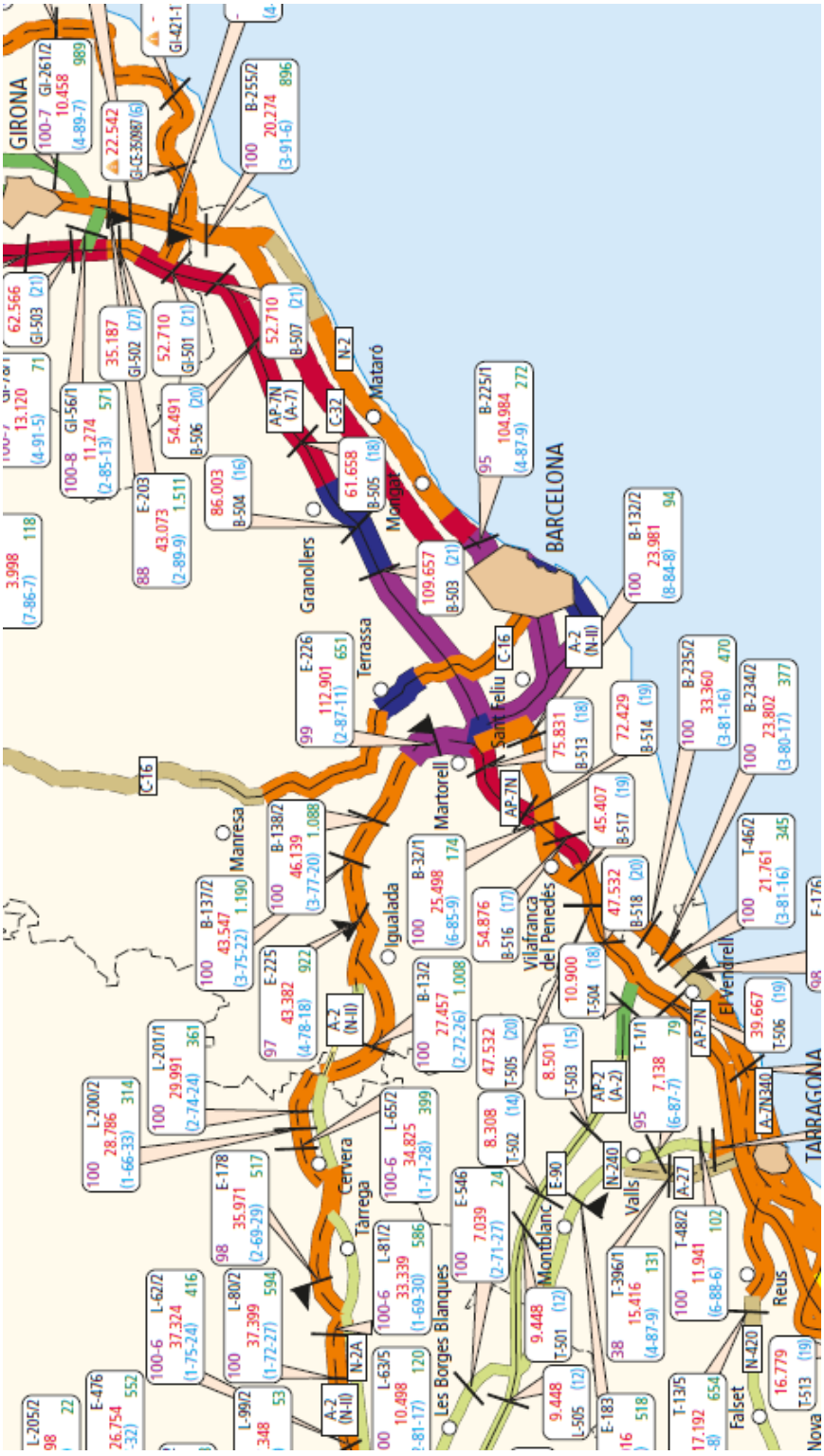
il·lustració 12: Vista del contorn de velocitat vertical 5 (Font: Pròpia)



il·lustració 13: Vista del contorn de velocitat vertical 6 (Font: Pròpia)

Annex B

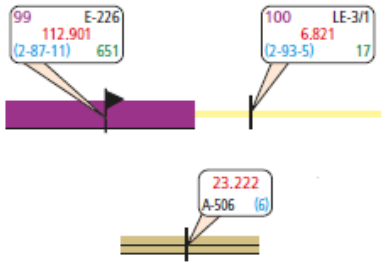
*Aquest mapa ha sigut extret de la pàgina web del Ministeri de Foment



Il·lustració 14: Mapa IMD 2017 (Font: Ministeri de Foment)

TRÁFICO EN LA RED DE CARRETERAS DEL ESTADO Y RED AUTONÓMICA PRIORITARIA(1). AÑO 2017

LEYENDA



E-226	Estación permanente núm. 226
MU-20/5	Estación semipermanente Murcia núm. 20
LE-3/1	Estación primaria León núm. 3
J-32/2	Estación secundaria Jaén núm. 32
A-506	Estación virtual de Peaje
112.901	Intensidad media diaria (I.M.D.) (veh./día)
(2-87-11)	Porcentaje de motos, vehículos ligeros y vehículos pesados
651	I.M.D. de vehículos extranjeros (veh./día)
(6)	Porcentaje de vehículos pesados en autopistas de peaje
99	Porcentaje de funcionamiento real de la estación
100-6	Estación secundaria que se comporta como primaria
100-7	Estación primaria o secundaria que se comporta como semipermanente
100-8	Estación primaria o secundaria que se comporta como permanente

SIMBOLOGÍA

- Estación permanente
- Estación de aforos fija semipermanente, primaria, secundaria o virtual en autopista de peaje
- Paso fronterizo
- EF España-Francia
- EP España-Portugal
- Núcleo urbano
- Capital de provincia
- Límite nacional
- Límite provincial

TITULARIDAD Y TIPO DE VÍA (4)

RED DE CARRETERAS DEL ESTADO

- Autovía, Autopista Libre y Multicarril
- Autopista de peaje
- Carretera Convencional

RED DE CARRETERAS AUTONÓMICAS (2)

- Autovía, Autopista Libre y Multicarril
- Autopista de peaje
- Carretera Convencional

(1) Se ha completado la Red de Carreteras del Estado (26.393 km) con parte de la Red Autonómica Prioritaria constituida por:
– Red Internacional [A-18, C-16 (antigua C-1411)]
– Red Básica de las Comunidades con alto grado de transferencia (Baleares, Canarias, País Vasco y Navarra)
– Red de gran capacidad autonómica (A-15, A-92, GC-1, GC-2, TF-1, TF-5, PM-1, PM-19, PM-27...)

(2) Los datos de tráfico de las carreteras autonómicas han sido extraídos de los Planos de Aforos de los organismos titulares de las vías.

(3) Días teóricos de funcionamiento al año de cada tipo de estación y número de estaciones en la Red de Carreteras del Estado. Año 2017.
Estación Permanente: 365 días. Número de estaciones: 562
Estación Semipermanente: 84 días. Número de estaciones: 76
Estación Primaria: 42 días. Número de estaciones: 397
Estación Secundaria: 12 días. Número de estaciones: 979
Autopista de peaje: 365 días. Número de estaciones: 318

(4) Se ha empleado la nueva denominación de carreteras, colocando debajo y entre paréntesis la anterior cuando esta ha sido cambiada.

- Sin datos
- I.M.D. de 0 a 1.000
- I.M.D. de 1.001 a 2.000
- I.M.D. de 2.001 a 5.000
- I.M.D. de 5.001 a 10.000
- I.M.D. de 10.001 a 15.000
- I.M.D. de 15.001 a 20.000
- I.M.D. de 20.001 a 50.000
- I.M.D. de 50.001 a 80.000
- I.M.D. de 80.001 a 100.000
- I.M.D. de más de 100.000

⚠ Datos de tráfico de las carreteras autonómicas pertenecientes al año 2016.

il·lustració 15: Llegenda mapa IMD 2017(Font: Ministeri de Foment)

Annex C

Classe de rugositat	Longitud de rugositat m	Índex de energia (%)	Tipo de paisatge
0	0,0002	100	Superfície del agua
0,5	0,0024	73	Terreny completament obert amb una superfície llisa, p.ex., pistes de formigó en els aeroports, gespa tallada, etc.
1	0,03	52	Àrea agrícola oberta sense tancats ni tanques i amb edificis molt dispersos. Només turons suaument arrodonides
1,5	0,055	45	Terreny agrícola amb algunes cases i tanques de 8 metres d'altura amb una distància aproximada de 1250 m.
2	0,1	39	Terreny agrícola amb algunes cases i tanques de 8 metres d'altura amb una distància aproximada de 500 m.
2,5	0,2	31	Terreny agrícola amb moltes cases, arbustos i plantes, o tanques de 8 metres d'altura amb una distància aproximada de 250 m.
3	0,4	24	Pobles, ciutats petites, terreny agrícola, amb molts o alts arbustos, boscos i terreny accidentat i molt desigual
3,5	0,8	18	Ciutats més grans amb edificis alts
4	1,6	13	Ciutats molt grans amb edificis alts i gratacels

Taula 1: Taula de classes de rugositats segons el paisatge (Font: DANISH WIND INDUSTRY ASSOCIATION)

Annex D

* Codi font pertanyent a Jeisson Giovanny Rincón Vivas i Cristian Reinel González Castro

```
“Option Infer On
Imports Snap, Snap.Create, Snap.UI.Input
Public Class MyProgram
Public Shared Sub Main()
InfoWindow.clear()
InfoWindow.WriteLine("-----------------------------------------------------------")
InfoWindow.WriteLine("--BIENVENIDO A LA APLICACIÓN DE DISEÑO DE TURBINAS SAVONIUS.--")
InfoWindow.WriteLine("-----------------------------------------------------------")
InfoWindow.WriteLine("A continuación elija el tipo de turbina a diseñar,")
InfoWindow.WriteLine("digite la velocidad del viento respectiva en su ubicación,")
InfoWindow.WriteLine("y la potencia en watts esperada para la turbina.")
Dim cue As String = "Selecciones el tipo de turbina savonius"
Dim title As String = "Seleccione el tipo de turbina"
Dim label As String = "Turbina"
Dim Turbinas As String() = {"Una Etapa", "Dos Etapas", "Tres Alabes", "Helicoidal" }
Dim style = Snap.UI.Block.EnumPresentationStyle.RadioBox
Dim choice = GetChoice(Turbinas, cue, title, label, style)
Dim title1 = "Parámetros Iniciales"
Dim label2 = "Velocidad del viento (m/s)"
Dim label3 = "Potencia (W)"
Dim veloc = GetDouble(cue, title1, label2, 0)
Dim pot = GetDouble(cue, title1, label3, 0)
Dim dens As Double = 1.225
Dim nmec As Double = 0.95
Dim nelec As Double = 0.9
Dim cp As Double = 0.2
Dim n1 As Double = nmec * nelec * cp
```

```
Dim pnom As Double = pot / n1
Dim factor As Double = dens * (veloc^3)
Dim area As Double = (2*pnom) / factor
Dim x As Double = System.Math.Sqrt(area/2)
Dim d As Double = x*1000
Dim h As Double = 2*d
Dim a As Double = d*6/11
Dim s As Double = a/6
Dim axis As Vector = Vector.AxisZ
Dim vnom As Double = ((2*pnom) / (area*n1))^(1/3)
If choice = 0
Dim p1,p2,p3,p4,p5,p6,p7,p8 as NX.Point
Dim p11,p111 as New Position
p1 = Point(-d/2,0)
p2 = Point(d/2,0)
p3 = Point((-d/2)+1.24,0)
p4 = Point(a/16,0)
p5 = Point((a/16)-1.24,0)
p6 = Point((d/2)-1.24,0)
P7 = Point(-a/16,0)
p8 = Point((-a/16)+1.24,0)
Dim alas As NX.Arc = Arc(((a/16)-((d/2)+(a/16))/2), 0, ((d/2)+(a/16))/2, 0, 180)
Dim ala3 As NX.Arc = Arc(((a/16)-((d/2)+(a/16))/2), 0, (((d/2)+(a/16))/2)-1.24, 0, 180)
Dim section As NX.Arc = Circle(0, 0, 12.5)
Dim ala2 As NX.Arc = Arc((-(a/16)+((d/2)+(a/16))/2), 0, ((d/2)+(a/16))/2, 180, 360)
Dim ala4 As NX.Arc = Arc((-(a/16)+((d/2)+(a/16))/2), 0, (((d/2)+(a/16))/2)-1.24, 180, 360)
p111= New Position(0, 0, -200)
section.center = p111
Dim e1, e2, e3, e4, e5 As NX.Extrude
e1 = Extrude( {section}, axis, h+800, 0)
e2 = Extrude( {alas}, axis, h, 0)
```

```
e3 = Extrude( {ala2}, axis, h, 0)
e4 = Extrude( {ala3}, axis, h, 0)
e5 = Extrude( {ala4}, axis, h, 0)
Dim tapa As NX.Arc = Circle(0, 0, 1.1*d/2)
Dim base As NX.Arc = Circle(0, 0, 1.1*d/2)
p11= New Position(0, 0, h)
base.center = p11
Dim e6, e7, e8, e9, e10, e11 As NX.Extrude
e6 = Extrude( {tapa}, axis, 1.24, 0)
e7 = Extrude( {base}, axis, 1.24, 0)
e8 = Extrude( {Line(p1, p3)}, axis, h, 0)
e9 = Extrude( {Line(p5, p4)}, axis, h, 0)
e10 = Extrude( {Line(p6, p2)}, axis, h, 0)
e11 = Extrude( {Line(p7, p8)}, axis, h, 0)
Dim p1111 as New Position
Dim e1111 As NX.Extrude
Dim section1 As NX.Arc = Circle(0, 0, 15)
p1111= New Position(0, 0, -100)
section1.center = p1111
e1111= Extrude( {section1}, axis, h+232.2, 0)
Else If choice = 1
Dim p9,p10,p11,p12,p13,p14,p15,p16,p91,p92,p93,p94,p95,p96,p97,p98 as NX.Point
Dim p111,p112,p113,p114,p115 as New Position
p9 = Point(-d/2,0)
p10 = Point(d/2,0)
p11 = Point((-d/2)+1.24,0)
p12 = Point(a/16,0)
p13 = Point((a/16)-1.24,0)
p14 = Point((d/2)-1.24,0)
P15 = Point(-a/16,0)
p16 = Point((-a/16)+1.24,0)
```

```
Dim alas As NX.Arc = Arc(((a/16)-((d/2)+(a/16))/2), 0, ((d/2)+(a/16))/2, 180, 360)
Dim ala3 As NX.Arc = Arc(((a/16)-((d/2)+(a/16))/2), 0, (((d/2)+(a/16))/2)-1.24, 180, 360)
Dim section As NX.Arc = Circle(0, 0, 12.5)
Dim ala2 As NX.Arc = Arc((-(a/16)+((d/2)+(a/16))/2), 0, ((d/2)+(a/16))/2, 0, 180)
Dim ala4 As NX.Arc = Arc((-(a/16)+((d/2)+(a/16))/2), 0, (((d/2)+(a/16))/2)-1.24, 0, 180)
p111= New Position(0, 0, -200)
section.center = p111
Dim e1, e2, e3, e4, e5 As NX.Extrude
e1 = Extrude( {section}, axis, h+800, 0)
e2 = Extrude( {alas}, axis, h/2, 0)
e3 = Extrude( {ala2}, axis, h/2, 0)
e4 = Extrude( {ala3}, axis, h/2, 0)
e5 = Extrude( {ala4}, axis, h/2, 0)
Dim tapa As NX.Arc = Circle(0, 0, 1.1*d/2)
Dim base As NX.Arc = Circle(0, 0, 1.1*d/2)
p112= New Position(0, 0, h)
base.center = p112
Dim e6, e7, e8, e9, e10, e11 As NX.Extrude
e6 = Extrude( {tapa}, axis, 1.24, 0)
e7 = Extrude( {base}, axis, 1.24, 0)
e8 = Extrude( {Line(p9, p11)}, axis, h/2, 0)
e9 = Extrude( {Line(p13, p12)}, axis, h/2, 0)
e10 = Extrude( {Line(p14, p10)}, axis, h/2, 0)
e11 = Extrude( {Line(p15, p16)}, axis, h/2, 0)
Dim tapamedia As NX.Arc = Circle(0, 0, 1.1*d/2)
p113= New Position(0, 0, h/2)
tapamedia.center = p113
Dim e12, e13, e14, e15, e16 As NX.Extrude
e12 = Extrude( {tapamedia}, axis, 1.24, 0)
Dim ala5 As NX.Arc = Arc(((a/16)-((d/2)+(a/16))/2), 0, ((d/2)+(a/16))/2, 270, 90)
Dim ala6 As NX.Arc = Arc(((a/16)-((d/2)+(a/16))/2), 0, (((d/2)+(a/16))/2)-1.24, 270, 90)
```

```
Dim ala7 As NX.Arc = Arc((-(a/16)+((d/2)+(a/16))/2), 0, ((d/2)+(a/16))/2, 90, 270)
Dim ala8 As NX.Arc = Arc((-(a/16)+((d/2)+(a/16))/2), 0, (((d/2)+(a/16))/2)-1.24, 90, 270)
p114= New Position(0,(+(-(d/2)+(a/16))/2) , h/2)
p115= New Position(0,(-(-(d/2)+(a/16))/2) , h/2)
ala5.center = p114
ala6.center = p114
ala7.center = p115
ala8.center = p115
e13 = Extrude( {ala5}, axis, h/2, 0)
e14 = Extrude( {ala6}, axis, h/2, 0)
e15 = Extrude( {ala7}, axis, h/2, 0)
e16 = Extrude( {ala8}, axis, h/2, 0)
p91 = Point(0,-d/2,h/2)
p92 = Point(0,d/2,h/2)
p93 = Point(0,(-d/2)+1.24,h/2)
p94 = Point(0,a/16,h/2)
p95 = Point(0,(a/16)-1.24,h/2)
p96 = Point(0,(d/2)-1.24,h/2)
P97 = Point(0,-a/16,h/2)
p98 = Point(0,(-a/16)+1.24,h/2)
Dim e17, e18, e19, e20 As NX.Extrude
e17 = Extrude( {Line(p91, p93)}, axis, h/2, 0)
e18 = Extrude( {Line(p95, p94)}, axis, h/2, 0)
e19 = Extrude( {Line(p96, p92)}, axis, h/2, 0)
e20 = Extrude( {Line(p97, p98)}, axis, h/2, 0)
Dim p1111 as New Position
Dim e1111 As NX.Extrude
Dim section1 As NX.Arc = Circle(0, 0, 15)
p1111= New Position(0, 0, -100)
section1.center = p1111
e1111= Extrude( {section1}, axis, h+232.2, 0)
```

```
Else If choice = 2
Dim p17,p18,p19,p20,p21,p22,p23,p24 as NX.Point
Dim p116,p117,p118,p119,p120 as New Position
p17 = Point(-d/2,0)
p18 = Point(d/2,0)
p19 = Point((-d/2)+1.24,0)
Line(p17, p19)
p20 = Point(a/16,0)
p21 = Point((a/16)-1.24,0)
Line(p21, p20)
p22 = Point((d/2)-1.24,0)
Line(p22, p18)
P23 = Point(-a/16,0)
p24 = Point((-a/16)+1.24,0)
Line(p23, p24)
Dim alas As NX.Arc = Arc(((a/16)-((d/2)+(a/16))/2), 0, ((d/2)+(a/16))/2, 60, 240)
Dim ala3 As NX.Arc = Arc(((a/16)-((d/2)+(a/16))/2), 0, (((d/2)+(a/16))/2)-1.24, 60, 240)
Dim section As NX.Arc = Circle(0, 0, 12.5)
Dim ala2 As NX.Arc = Arc((-(a/16)+((d/2)+(a/16))/2), 0, ((d/2)+(a/16))/2, 180, 360)
Dim ala4 As NX.Arc = Arc((-(a/16)+((d/2)+(a/16))/2), 0, (((d/2)+(a/16))/2)-1.24, 180, 360)
p116= New Position(0, 0, -200)
section.center = p116
Dim ala5 As NX.Arc = Arc((-(a/16)+((d/2)+(a/16))/2), 0, ((d/2)+(a/16))/2, 300, 120)
Dim ala6 As NX.Arc = Arc((-(a/16)+((d/2)+(a/16))/2), 0, (((d/2)+(a/16))/2)-1.24, 300, 120)
p117= New Position(a/4, 0.866025403*(a/2), 0)
alas.center = p117
ala3.center = p117
p118= New Position(-a/2, 0, 0)
ala2.center = p118
ala4.center = p118
p119= New Position(a/4, -0.866025403*(a/2), 0)
```

```
ala5.center = p119
ala6.center = p119
Dim e1, e2, e3, e4, e5, e8, e9 As NX.Extrude
e1 = Extrude( {section}, axis, h+800, 0)
e2 = Extrude( {alas}, axis, h, 0)
e3 = Extrude( {ala2}, axis, h, 0)
e4 = Extrude( {ala3}, axis, h, 0)
e5 = Extrude( {ala4}, axis, h, 0)
e8 = Extrude( {ala5}, axis, h, 0)
e9 = Extrude( {ala6}, axis, h, 0)
Dim tapa As NX.Arc = Circle(0, 0, 1.1*d/2)
Dim base As NX.Arc = Circle(0, 0, 1.1*d/2)
p120= New Position(0, 0, h)
base.center = p120
Dim e6, e7, e10 As NX.Extrude
e6 = Extrude( {tapa}, axis, 1.24, 0)
e7 = Extrude( {base}, axis, 1.24, 0)
Dim p1111 as New Position
Dim e1111 As NX.Extrude
Dim section1 As NX.Arc = Circle(0, 0, 15)
p1111= New Position(0, 0, -100)
section1.center = p1111
e1111= Extrude( {section1}, axis, h+232.2, 0)
Else If choice = 3
Dim p25,p26,p27,p28,p29,p30,p31,p32 as NX.Point
Dim p121,p230,p231 as New Position
p25 = Point(-d/2,0)
p26 = Point(d/2,0)
p27 = Point((-d/2)+1.24,0)
Line(p25, p27)
p28 = Point(a/16,0)
```

```
p29 = Point((a/16)-1.24,0)
Line(p29, p28)
p30 = Point((d/2)-1.24,0)
Line(p30, p26)
P31 = Point(-a/16,0)
p32 = Point((-a/16)+1.24,0)
Line(p31, p32)
Dim alas As NX.Arc = Arc(((a/16)-((d/2)+(a/16))/2), 0, ((d/2)+(a/16))/2, 0, 180)
Dim ala3 As NX.Arc = Arc(((a/16)-((d/2)+(a/16))/2), 0, (((d/2)+(a/16))/2)-1.24, 0, 180)
Dim section As NX.Arc = Circle(0, 0, 12.5)
Dim ala2 As NX.Arc = Arc((-(a/16)+((d/2)+(a/16))/2), 0, ((d/2)+(a/16))/2, 180, 360)
Dim ala4 As NX.Arc = Arc((-(a/16)+((d/2)+(a/16))/2), 0, (((d/2)+(a/16))/2)-1.24, 180, 360)
Dim e1, e2, e3, e4, e5 As NX.Extrude
e1 = Extrude( {section}, axis, h+600, 0)
Dim ala11 As NX.Arc = Arc((-(a/16)+((d/2)+(a/16))/2), 0, ((d/2)+(a/16))/2, 180, 360)
Dim tapa As NX.Arc = Circle(0, 0, 1.1*d/2)
Dim base As NX.Arc = Circle(0, 0, 1.1*d/2)
p121= New Position(0, 0, h)
p230= New Position((-(a/16)+((d/2)+(a/16))/2), 0, h)
base.center = p121
Dim e6, e7 As NX.Extrude
e6 = Extrude( {tapa}, axis, 1.24, 0)
e7 = Extrude( {base}, axis, 1.24, 0)
ala11.center = p230
Dim ala10 As NX.Arc = Arc(((a/16)-((d/2)+(a/16))/2), 0, ((d/2)+(a/16))/2, 0, 180)
Dim primaryCurves As NX.ICurve() = {ala11, alas}
Dim u00, u01, u02, u03 As Position
Dim u10, u11, u12, u13 As Position
Dim u20, u21, u22, u23 As Position
u00 = {-d/2,0, 0} : u01 = {-d/2,-((d/2)+(a/16)/2) , h/3} : u02 = {d/6,-2*((d/2)+(a/16)/2) , 2*h/3} : u03 = {d/2,0,
h}
```

```
u10 = {-(d/2-(((d/2)+(a/16))/2)), ((d/2)+(a/16))/2, 0} : u11 = {-((((((d/2)+(a/16))/2)-(-(((d/2)+(a/16))/2))))/3), a, h/3} : u12 = {-(2*((((d/2)+(a/16))/2)-(-(((d/2)+(a/16))/2))))/3), -a, 2*h/3} : u13 = {(d/2-(((d/2)+(a/16))/2)), -((d/2)+(a/16))/2, h}

u20 = {a/16, 0, 0} : u21 = {a/8, a/2, h/3} : u22 = {-a/8, a/2, 2*h/3} : u23 = {-a/16, 0, h}

Dim cc1 = BezierCurve(u00, u01, u02, u03)

Dim cc2 = BezierCurve(u10, u11, u12, u13)

Dim cc3 = BezierCurve(u20, u21, u22, u23)

Dim crossCurves As NX.ICurve() = { cc1, cc2, cc3 }

Dim meshSurface = ThroughCurveMesh(primaryCurves, crossCurves)

p231= New Position(-(-(a/16)+((d/2)+(a/16))/2), 0, h)

ala10.center = p231

Dim primaryCurves1 As NX.ICurve() = {ala2, ala10}

Dim v00, v01, v02, v03 As Position

Dim v10, v11, v12, v13 As Position

Dim v20, v21, v22, v23 As Position

v00 = {d/2,0, 0} : v01 = {d/2,((d/2)+(a/16)/2) , h/3} : v02 = {-d/6, 2*((d/2)+(a/16)/2) , 2*h/3} : v03 = {-d/2,0, h}

v10 = {(d/2-(((d/2)+(a/16))/2)), -((d/2)+(a/16))/2, 0} : v11 = {((((((d/2)+(a/16))/2)-(-(((d/2)+(a/16))/2))))/3), -a, h/3} : v12 = {(2*((((d/2)+(a/16))/2)-(-(((d/2)+(a/16))/2))))/3), a, 2*h/3} : v13 = {-(d/2-(((d/2)+(a/16))/2)), ((d/2)+(a/16))/2, h}

v20 = {-a/16, 0, 0} : v21 = {-a/8, -a/2, h/3} : v22 = {a/8, -a/2, 2*h/3} : v23 = {a/16, 0, h}

Dim cs1 = BezierCurve(v00, v01, v02, v03)

Dim cs2 = BezierCurve(v10, v11, v12, v13)

Dim cs3 = BezierCurve(v20, v21, v22, v23)

Dim crossCurves1 As NX.ICurve() = { cs1, cs2, cs3 }

Dim meshSurfac = ThroughCurveMesh(primaryCurves1, crossCurves1)

Dim p1111 as New Position

Dim e1111 As NX.Extrude

Dim section1 As NX.Arc = Circle(0, 0, 15)

p1111= New Position(0, 0, -100)

section1.center = p1111

e1111= Extrude( {section1}, axis, h+232.2, 0)

End If
```

```
Dim estruc As NX.Line() = Rectangle( {-57.5,1.4*d/2,-105}, {57.5,1.45*d/2,-105})

Dim estruc1 As NX.Line() = Rectangle( {-57.5,-1.4*d/2,-105}, {57.5,-1.45*d/2,-105})

Dim estruc2 As NX.Line() = Rectangle( {-57.5,-1.4*d/2,-105}, {-47.5,1.4*d/2,-105})

Dim estruc3 As NX.Line() = Rectangle( {57.5,-1.4*d/2,-105}, {47.5,1.4*d/2,-105})

Dim estruc4 As NX.Line() = Rectangle( {-47.5,1.4*d/2,-75}, {47.5,1.45*d/2,-75})

Dim estruc5 As NX.Line() = Rectangle( {-47.5,-1.4*d/2,-75}, {47.5,-1.45*d/2,-75})

Dim estruc6 As NX.Line() = Rectangle( {-1.4*d/2,-1.4*d/2,h+175}, {1.4*d/2,-((1.4*d/2)+30),h+175})

Dim estruc7 As NX.Line() = Rectangle( {-1.4*d/2,1.4*d/2,h+175}, {1.4*d/2,(1.4*d/2)+30,h+175})

Dim estruc8 As NX.Line() = Rectangle( {-1.4*d/2,(1.4*d/2)+30,h+175}, {-((1.4*d/2)+30),-
((1.4*d/2)+30),h+175})

Dim estruc9 As NX.Line() = Rectangle( {1.4*d/2,(1.4*d/2)+30,h+175}, {(1.4*d/2)+30,-((1.4*d/2)+30),h+175})

Dim u, v, w ,z As Vector

w = New Vector(1.4*d/2,0,(h+175)-(h/3) )

z = New Vector(-1.4*d/2,0,(h+175)-(h/3) )

Dim hip1 As Double = ((h+175)-(h/3))*((h+175)-(h/3))

Dim hip2 As Double = (1.4*d/2)*(1.4*d/2)

Dim estruc10 As NX.Line() = Rectangle( {-15,1.4*d/2,h/3}, {15,1.45*d/2,h/3})

Dim estruc11 As NX.Line() = Rectangle( {-15,-1.4*d/2,h/3}, {15,-1.45*d/2,h/3})

Dim estruc12 As NX.Line() = Rectangle( {-57.5,-57.5,-109}, {57.5,57.5,-109})

Dim estruc13 As NX.Line() = Rectangle( {57.5,-1.4*d/2,h+175}, {47.5,1.4*d/2,h+175})

Dim estruc14 As NX.Line() = Rectangle( {-57.5,-1.4*d/2,h+175}, {-47.5,1.4*d/2,h+175})

Dim estruc15 As NX.Line() = Rectangle( {-57.5,-57.5,h+171}, {57.5,57.5,h+171})

Dim estruc16 As NX.Line() = Rectangle( {57.5,-((1.4*d/2)+30),h+355}, {47.5,(1.4*d/2)+30,h+355})

Dim estruc17 As NX.Line() = Rectangle( {-57.5,-((1.4*d/2)+30),h+355}, {-47.5,(1.4*d/2)+30,h+355})

Dim estruc18 As NX.Line() = Rectangle( {-57.5,-1.4*d/2,h+205}, {-47.5,-1.45*d/2,h+205})

Dim estruc19 As NX.Line() = Rectangle( {57.5,-1.4*d/2,h+205}, {47.5,-1.45*d/2,h+205})

Dim estruc20 As NX.Line() = Rectangle( {-57.5,1.4*d/2,h+205}, {-47.5,1.45*d/2,h+205})

Dim estruc21 As NX.Line() = Rectangle( {57.5,1.4*d/2,h+205}, {47.5,1.45*d/2,h+205})

Dim estruc22 As NX.Line() = Rectangle( {-((1.4*d/2)+60),-((1.4*d/2)+60),h+205}, {-((1.4*d/2)-100),-
((1.4*d/2)-100),h+205})

Dim estruc23 As NX.Line() = Rectangle( {((1.4*d/2)+60),((1.4*d/2)+60),h+205}, {((1.4*d/2)-100),((1.4*d/2)-
100),h+205})
```

```
Dim estruc24 As NX.Line() = Rectangle( {((1.4*d/2)+60),-((1.4*d/2)+60),h+205}, {((1.4*d/2)-100),-((1.4*d/2)-100),h+205})

Dim estruc25 As NX.Line() = Rectangle( {-((1.4*d/2)+60),((1.4*d/2)+60),h+205}, {-((1.4*d/2)-100),((1.4*d/2)-100),h+205})

Dim estruc26 As NX.Line() = Rectangle( {-((1.4*d/2)+35),-((1.4*d/2)+35),h+209}, {-((1.4*d/2)-50),-((1.4*d/2)-50),h+209})

Dim estruc27 As NX.Line() = Rectangle( {((1.4*d/2)+35),((1.4*d/2)+35),h+209}, {((1.4*d/2)-50),((1.4*d/2)-50),h+209})

Dim estruc28 As NX.Line() = Rectangle( {-((1.4*d/2)+35),((1.4*d/2)+35),h+209}, {-((1.4*d/2)-50),((1.4*d/2)-50),h+209})

Dim estruc29 As NX.Line() = Rectangle( {((1.4*d/2)+35),-((1.4*d/2)+35),h+209}, {((1.4*d/2)-50),-((1.4*d/2)-50),h+209})

Dim estruc30 As NX.Line() = Rectangle( {-47.5,-1.4*d/2,h+355}, {47.5,-((1.4*d/2)+30),h+355})

Dim estruc31 As NX.Line() = Rectangle( {-47.5,1.4*d/2,h+355}, {47.5,((1.4*d/2)+30),h+355})

Dim estruc32 As NX.Line() = Rectangle( {-((1.4*d/2)+85),-((1.4*d/2)+85),h+1104.5}, {-((1.4*d/2)-100),-((1.4*d/2)-100),h+1104.5})

Dim estruc33 As NX.Line() = Rectangle( {((1.4*d/2)+85),((1.4*d/2)+85),h+1104.5}, {((1.4*d/2)-100),((1.4*d/2)-100),h+1104.5})

Dim estruc34 As NX.Line() = Rectangle( {-((1.4*d/2)+85),((1.4*d/2)+85),h+1104.5}, {-((1.4*d/2)-100),((1.4*d/2)-100),h+1104.5})

Dim estruc35 As NX.Line() = Rectangle( {((1.4*d/2)+85),-((1.4*d/2)+85),h+1104.5}, {((1.4*d/2)-100),-((1.4*d/2)-100),h+1104.5})

Dim estruc36 As NX.Arc = Circle(0, 0, 15)

Dim p200,p201,p202,p203,p204,p205,p206,p207,p208,p209,p301 as New Position

p200= New Position(0, 0, -109)

estruc36.center = p200

Dim estruc37 As NX.Arc = Circle(0, 0, 5)

p201= New Position(35, 35, -109)

estruc37.center = p201

Dim estruc38 As NX.Arc = Circle(0, 0, 5)

p202= New Position(-35, -35, -109)

estruc38.center = p202

Dim estruc39 As NX.Arc = Circle(0, 0, 5)

p203= New Position(35, -35, -109)

estruc39.center = p203
```

```
Dim estruc40 As NX.Arc = Circle(0, 0, 5)

p204= New Position(-35, 35, -109)

estruc40.center = p204

Dim estruc41 As NX.Arc = Circle(0, 0, 15)

p205= New Position(0, 0, h+171)

estruc41.center = p205

Dim estruc42 As NX.Arc = Circle(0, 0, 5)

p206= New Position(35, 35, h+171)

estruc42.center = p206

Dim estruc43 As NX.Arc = Circle(0, 0, 5)

p207= New Position(-35, -35, h+171)

estruc43.center = p207

Dim estruc44 As NX.Arc = Circle(0, 0, 5)

p208= New Position(35, -35, h+171)

estruc44.center = p208

Dim estruc45 As NX.Arc = Circle(0, 0, 5)

p209= New Position(-35, 35, h+171)

estruc45.center = p209

Dim estruc46 As NX.Line() = Rectangle( {((1.4*d/2)+35),((1.4*d/2)-50),h+604.5}, {((1.4*d/2)-50),-((1.4*d/2)-
50),h+604.5})

Dim estruc47 As NX.Line() = Rectangle( {-((1.4*d/2)+35),((1.4*d/2)-50),h+604.5}, {-((1.4*d/2)-50),-
((1.4*d/2)-50),h+604.5})

Dim estruc48 As NX.Line() = Rectangle( {-((1.4*d/2)-50),d/5,h+604.5}, {((1.4*d/2)-50),(d/5)-50,h+604.5})

Dim estruc49 As NX.Line() = Rectangle( {-((1.4*d/2)-50),-d/5,h+604.5}, {((1.4*d/2)-50),-((d/5)-50),h+604.5})

Dim estruc50 As NX.Arc = Circle(0, 0, 15)

p301= New Position(0, 0, h+268.5)

estruc50.center = p301

Dim e102, e103, e104, e105, e106, e107, e108, e109, e110, e111, e112, e113, e114, e115, e116, e117, e118,
e119, e120, e121, e122, e123, e124, e125, e126, e127, e128, e129, e130 As NX.Extrude

Dim e131, e132, e133, e134, e135, e136, e137, e138, e139, e140, e141, e142, e143, e144, e145, e146, e147,
e148, e149, e150, e151, e152, e153 As NX.Extrude

e102 = Extrude(estruc, axis, 30)
```

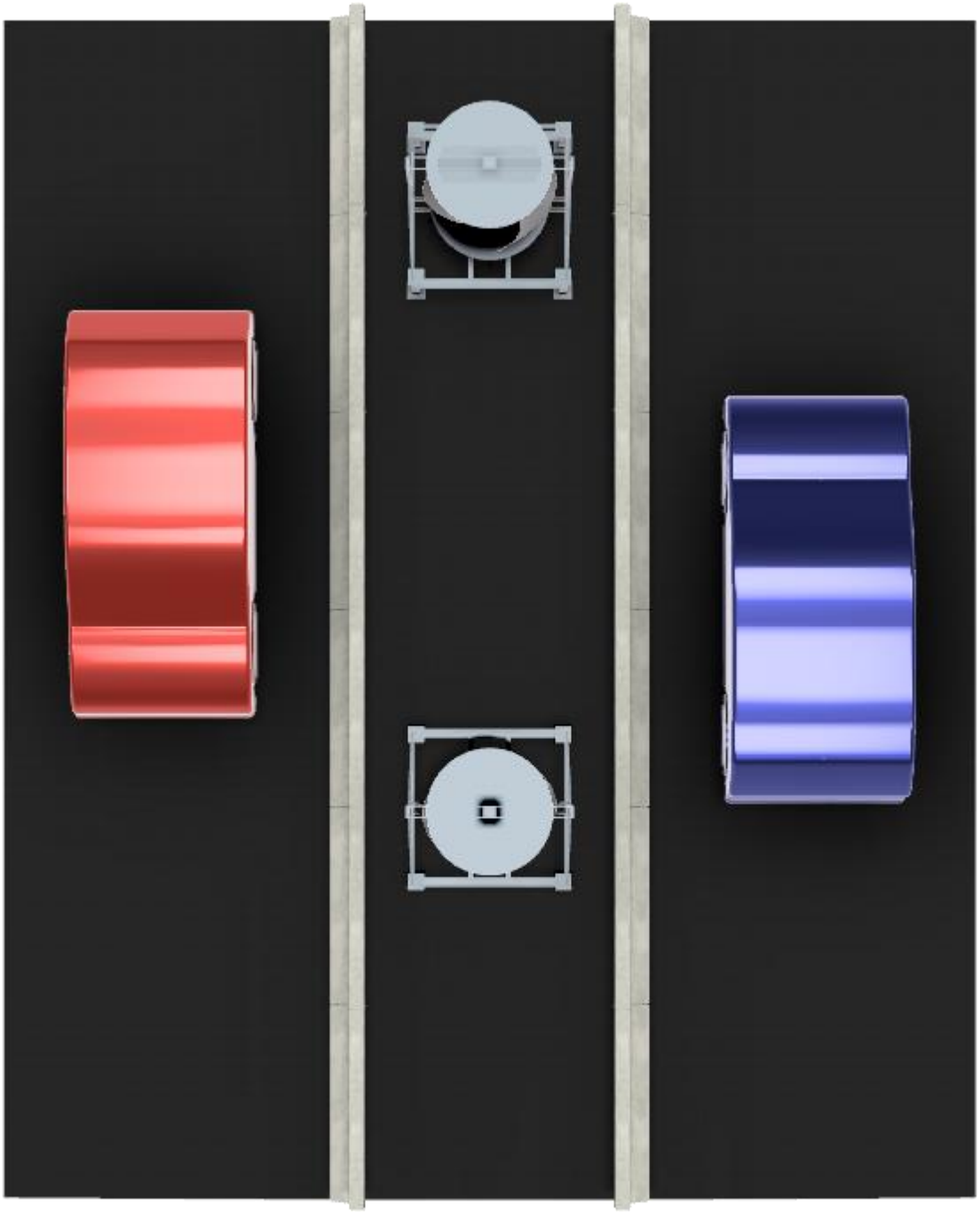
```
e103 = Extrude(estruc1, axis, 30)
e104 = Extrude(estruc2, axis, 30)
e105 = Extrude(estruc3, axis, 30)
e106 = Extrude(estruc4, axis, h+250)
e107 = Extrude(estruc5, axis, h+250)
e108 = Extrude(estruc6, axis, 30)
e109 = Extrude(estruc7, axis, 30)
e110 = Extrude(estruc8, axis, 30)
e111 = Extrude(estruc9, axis, 30)
e112 = Extrude(estruc10, w, System.Math.Sqrt(hip1 + hip2))
e113 = Extrude(estruc10, z, System.Math.Sqrt(hip1 + hip2))
e114 = Extrude(estruc11, w, System.Math.Sqrt(hip1 + hip2))
e115 = Extrude(estruc11, z, System.Math.Sqrt(hip1 + hip2))
e116 = Extrude(estruc12, axis, 4)
e117 = Extrude(estruc13, axis, 30)
e118 = Extrude(estruc14, axis, 30)
e119 = Extrude(estruc15, axis, 4)
e120 = Extrude(estruc16, axis, 30)
e121 = Extrude(estruc17, axis, 30)
e122 = Extrude(estruc18, axis, 150)
e123 = Extrude(estruc19, axis, 150)
e124 = Extrude(estruc20, axis, 150)
e125 = Extrude(estruc21, axis, 150)
e126 = Extrude(estruc22, axis, 4)
e127 = Extrude(estruc23, axis, 4)
e128 = Extrude(estruc24, axis, 4)
e129 = Extrude(estruc25, axis, 4)
e130 = Extrude(estruc26, axis, 900)
e131 = Extrude(estruc27, axis, 900)
e132 = Extrude(estruc28, axis, 900)
e133 = Extrude(estruc29, axis, 900)
```

```
e134 = Extrude(estruc30, axis, 30)
e134 = Extrude(estruc31, axis, 30)
e135 = Extrude(estruc32, axis, 4)
e136 = Extrude(estruc33, axis, 4)
e137 = Extrude(estruc34, axis, 4)
e138 = Extrude(estruc35, axis, 4)
e139 = Extrude( {estruc36}, axis, 4)
e140 = Extrude( {estruc37}, axis, 4)
e141 = Extrude( {estruc38}, axis, 4)
e142 = Extrude( {estruc39}, axis, 4)
e143 = Extrude( {estruc40}, axis, 4)
e144 = Extrude( {estruc41}, axis, 4)
Dim cut As NX.Boolean = Subtract(e116,e139,e140, e141, e142, e143 )
e145 = Extrude( {estruc42}, axis, 4)
e146 = Extrude( {estruc43}, axis, 4)
e147 = Extrude( {estruc44}, axis, 4)
e148 = Extrude( {estruc45}, axis, 4)
Dim cut6 As NX.Boolean = Subtract(e119,e144,e145,e146,e147,e148 )
e149 = Extrude(estruc46, axis, 50)
e150 = Extrude(estruc47, axis, 50)
e151 = Extrude(estruc48, axis, 50)
e152 = Extrude(estruc49, axis, 50)
Dim theSession As NXOpen.Session = NXOpen.Session.GetSession()
Dim workPart As NXOpen.Part = theSession.Parts.Work
Dim markId11 As NXOpen.Session.UndoMarkId
markId11 = theSession.SetUndoMark(NXOpen.Session.MarkVisibility.Visible, "Iniciar")
theSession.SetUndoMarkName(markId11, "Cuadro de diálogo Mostrar y Ocultar")
Dim markId21 As NXOpen.Session.UndoMarkId
markId21 = theSession.SetUndoMark(NXOpen.Session.MarkVisibility.Visible, "Ocultar Curvas")
Dim numberHidden1 As Integer
```

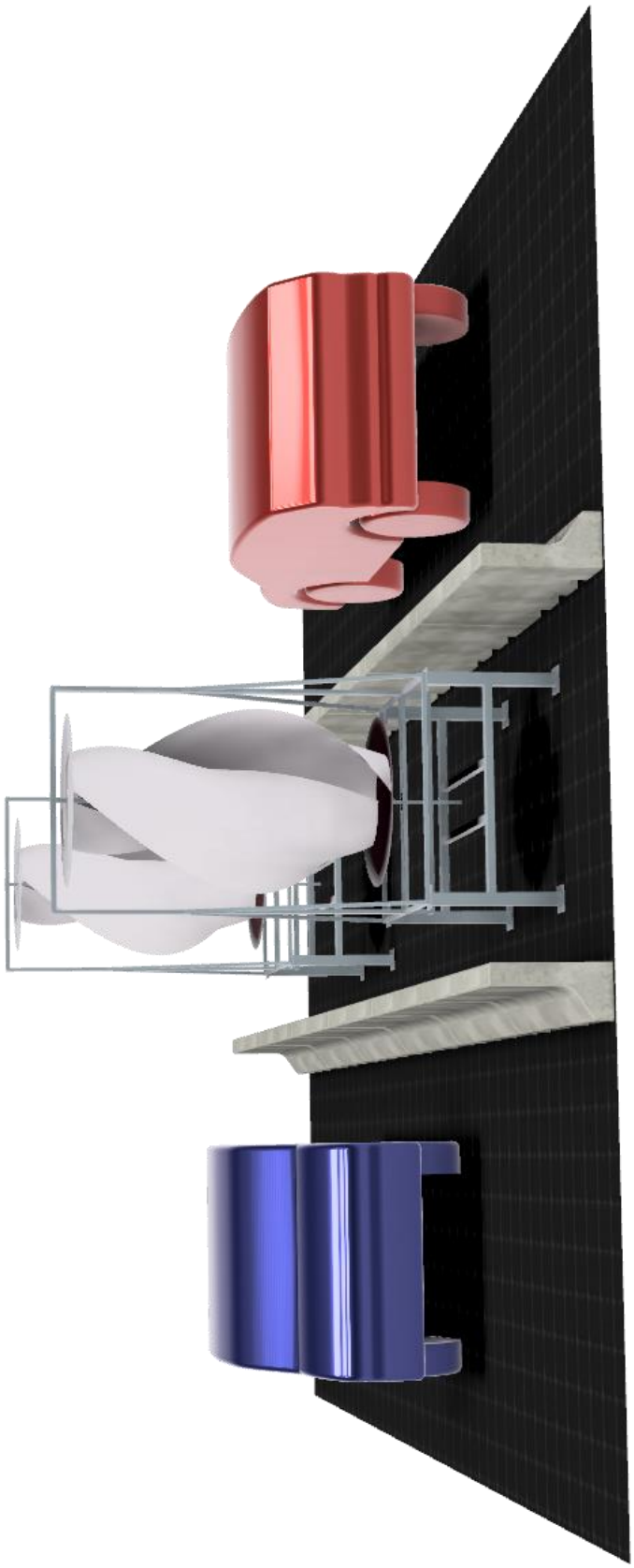
```
numberHidden1 = theSession.DisplayManager.HideByType("SHOW_HIDE_TYPE_CURVES",
NXOpen.DisplayManager.ShowHideScope.AnyInAssembly)

Dim nErrs11 As Integer

nErrs11 = theSession.UpdateManager.DoUpdate(markId21)

workPart.ModelingViews.WorkView.FitAfterShowOrHide(NXOpen.View.ShowOrHideType.HideOnly)

Dim markId31 As NXOpen.Session.UndoMarkId

markId31 = theSession.SetUndoMark(NXOpen.Session.MarkVisibility.Visible, "Ocultar Curvas")

Dim numberHidden2 As Integer

numberHidden2 = theSession.DisplayManager.HideByType("SHOW_HIDE_TYPE_CURVES",
NXOpen.DisplayManager.ShowHideScope.AnyInAssembly)

Dim nErrs21 As Integer

nErrs21 = theSession.UpdateManager.DoUpdate(markId31)

Dim exists1 As Boolean

exists1 = theSession.DoesUndoMarkExist(markId31, "Ocultar Curvas")

theSession.DeleteUndoMark(markId31, "Ocultar Curvas")

workPart.ModelingViews.WorkView.FitAfterShowOrHide(NXOpen.View.ShowOrHideType.HideOnly)

theSession.SetUndoMarkName(markId11, "Mostrar y Ocultar")

theSession.DeleteUndoMark(markId11, Nothing)

' ----------------------Tabla-----------------------

InfoWindow.WriteLine("-----------------------------------------------------------")

InfoWindow.WriteLine(" PRINCIPALES PARÁMETROS ")

InfoWindow.WriteLine("-----------------------------------------------------------")

InfoWindow.WriteLine(" Velocidad del viento (m/s) (v) " & veloc)

InfoWindow.WriteLine("-----------------------------------------------------------")

InfoWindow.WriteLine(" Potencia requerida (w) (P) " & pot)

InfoWindow.WriteLine("-----------------------------------------------------------")

InfoWindow.WriteLine(" Potencia nominal (w) (Pnom) " & pnom)

InfoWindow.WriteLine("-----------------------------------------------------------")

InfoWindow.WriteLine(" Área de barrido (m^2) (A) " & area)

InfoWindow.WriteLine("-----------------------------------------------------------")

InfoWindow.WriteLine(" Diametro de las tapas (mm) (D) " & 1.1*d)

InfoWindow.WriteLine("-----------------------------------------------------------")
```

```
InfoWindow.WriteLine(" Diametro de la turbina (mm) (d) " & d)
InfoWindow.WriteLine("-------------------------------------------------------")
InfoWindow.WriteLine(" Altura de la turbina (mm) (h) " & h)
InfoWindow.WriteLine("-------------------------------------------------------")
InfoWindow.WriteLine(" Altura de la estructura (mm) (H) " & h+1104.5)
InfoWindow.WriteLine("-------------------------------------------------------")
InfoWindow.WriteLine(" Parámetro (a) de turbina (mm) (a) " & a)
InfoWindow.WriteLine("-------------------------------------------------------")
InfoWindow.WriteLine(" Parámetro (s) de turbina (mm) (s) " & s)
InfoWindow.WriteLine("-------------------------------------------------------")
InfoWindow.WriteLine(" Velocidad nóminal (m/s)(Vnom) " & vnom)
InfoWindow.WriteLine("-------------------------------------------------------")
InfoWindow.WriteLine(" Altura de soportes (mm) (H1) " & 1000)
InfoWindow.WriteLine("-------------------------------------------------------")
InfoWindow.WriteLine(" Altura H2 (mm) (H2) " & 1000)
InfoWindow.WriteLine("-------------------------------------------------------")
InfoWindow.WriteLine(" Altura H3 (mm) (H2) " & h/3)
InfoWindow.WriteLine("-------------------------------------------------------")
InfoWindow.WriteLine(" Ancho de la estructura (mm) (A) " & 1.45*d)
InfoWindow.WriteLine("-------------------------------------------------------")
InfoWindow.WriteLine(" Ancho de soportes (mm) (E) " & 80)
InfoWindow.WriteLine("-------------------------------------------------------")
InfoWindow.WriteLine(" Ancho platinas de anclaje(mm) (P) " & 180)
InfoWindow.WriteLine("-------------------------------------------------------")
End Sub
End Class”
```

Annex E



il·lustració 16: Vista zenital de l'escenari (Font: Pròpia)



il·lustració 17: Vista frontal de l'escenari

Annex F

FT – 200P

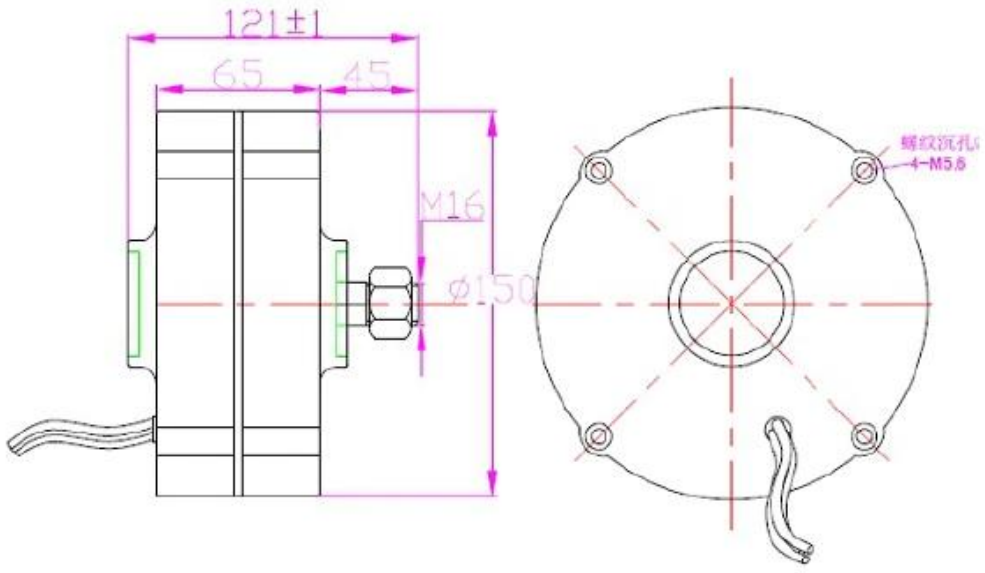
Wuxi Feng Teng New Energy

Technology Development Co., Ltd

Technical data of 200watts 12v 24volts low speed permanent magnet alternator

Model	FT-200P
Rated Power(w)	200w
Max Power(w)	240w
Rated Voltage（v)	12/24v
Rated rotated speed(r/m)	600r/m
Top net weight(kg)	3.4kg
Output Current	AC
Start Torque(N*M):	0.12Nm
generator	3 phase permanent magnet synchronous generator
Insulation Class:	F
Service Life:	More Than 20 years
Bearing	HRB or for your order
Shaft Material	stainless steel
Shell Material	aluminum alloy
Permanent Magnet Material	Rare Earth NdFeB
Protection Grade	IP54
Lubrication	Lubrication Grease
Working temperature	-40℃ - 80 ℃
Permanent magnet generator	

Dimension of 200watts 12v 24volts low speed permanent magnet alternator



200 watts low speed permanent magnet alternator

Product Overview

Special design Permanent Magnet Generator AC Alternator for Vertical Wind Turbine Generator.

Product Features:

1. With the best NdFeB Permanent Magnet, high-grade pure copper winding, the generator can product power stably and high efficiently.
2. Specially-designed rotor and rotator, low resistancemoment in start-up, good at cooling
3. Gearless, direct -drive, and low rev rare earth Permanent Magnet Generator, easy and safe for operating and maintainance.
4. Die casting alluminum alloy case, anti- corrosion, acid and alkali resistant, anti salt corrosion

Double shafts

Single shaft

Permanent Magnet Generator AC Alternator for Vertical Wind Turbine Generator 200W

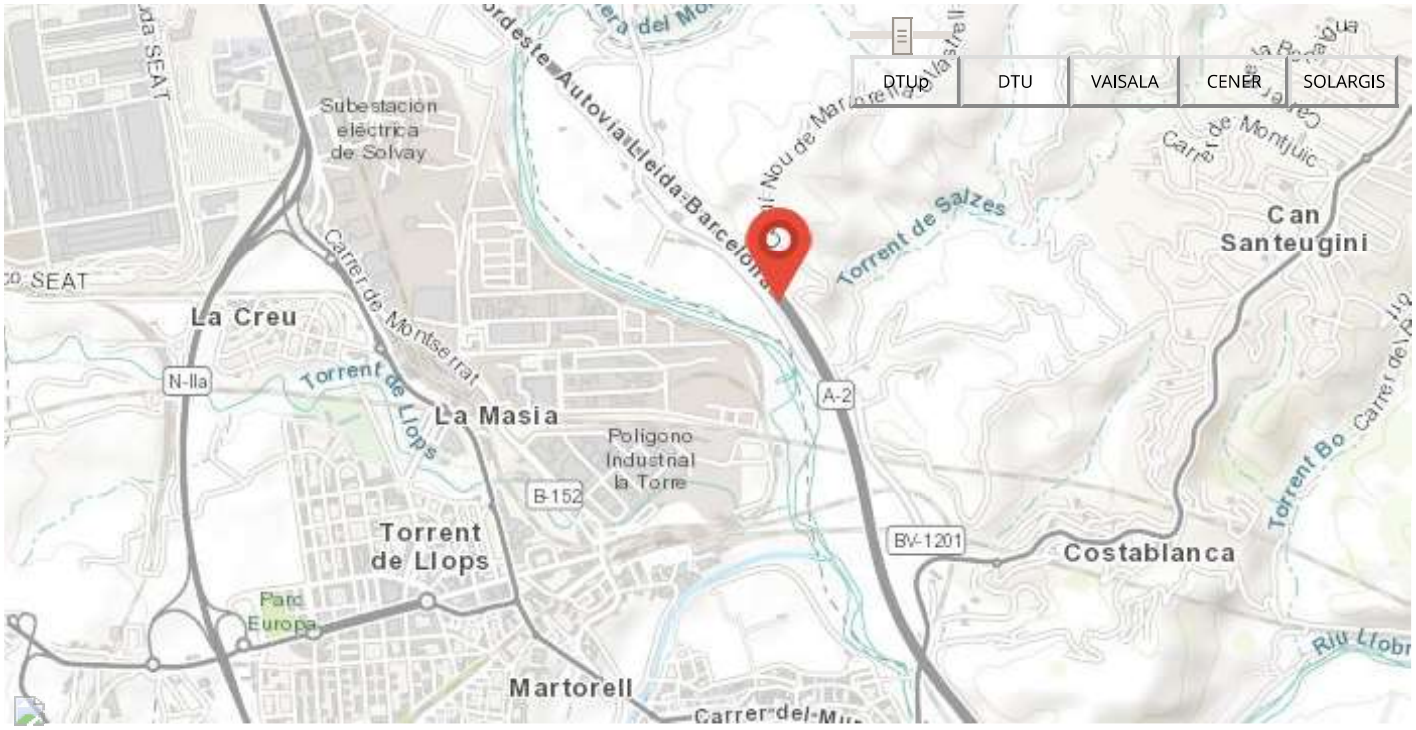
Annex G

CÁLCULO DE PRODUCCIÓN

Aerogenerador Estudio

ATLAS EÓLICO Y SOLAR MUNDIAL:

Pulsa en el mapa y averigua la energía eólica y solar disponible en esa ubicación



Este atlas eólico y solar combina las principales fuentes de datos internacionales, para determinar con gran exactitud los cálculos derivados del mismo. Las fuentes consultadas son: PVGIS, para energía solar y DTU, MERRA-2, VAISALA y BBDD propia la cual parte con el origen de la NASA corregido. Estas fuentes de datos son calculos internacionales y además de ellas para cálculos en España, se usa tamién en combinación la fuente de datos del CENER. No obstante, y dada la complejidad de los cálculos pueden existir márgenes de error en las medias de viento que pueden variar del 1 al 15%, también es importante considerar que no se aplican pérdidas por turbulencias de objetos cercanos.

COORDENADAS MANUALES

Recurso eólico

38.9kWh/día

Vel.media:

3.1

m/s

Velocidad viento a altura de buje

Si usted conoce la velocidad de viento exacta, puede introducirla manualmente.
Esta estimación de viento puede contener un error de hasta el 15%, es importante considerar la posible merma derivada de este error.

Energía eólica

Considerando la producción del Enair 200

Latitud: 41.487009
Longitud: 1.932621
Altitud: 67.6 m.
Densidad aire: 105.70%
Potencia media: 1.62kW
Energía: 14217kWh/year
Energía: 1185kWh/month

3.84toneladas/año

Ahorro de CO2

Ahorro de CO2 en toneladas que se evita tirar a la atmósfera.

592árboles sembrados/Ha

Emisión de CO2

Contáctanos (https://www.enair.es/es/contacto)

Realizar la siembra de 592 árboles equivale a la no emisión de 96 toneladas de CO2 durante los veinticinco años que tienen de vida útil.

3838.59euros/año

Ahorro económico

Precio:

0,27

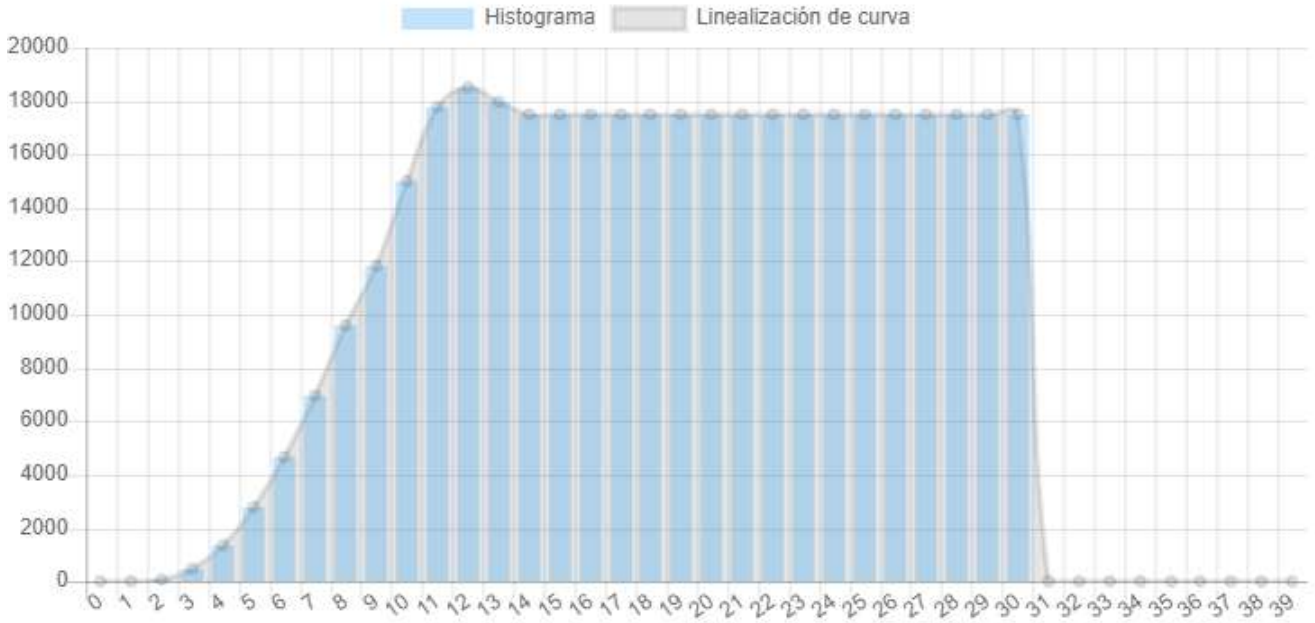
€/kWh

Detalle y fuente de datos:

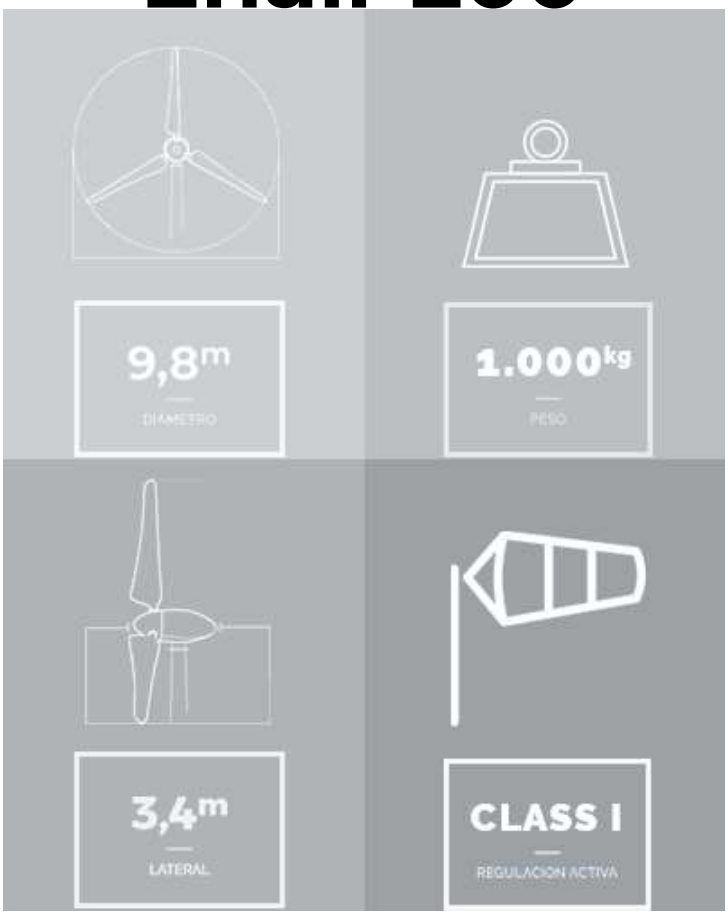
Fuente de datos	Altura hub (m)	Velocidad media (m/s)	Grado de confianza	Dispersión zona (m/s)	Weibull C	Weibull K	Rosa de vientos	Variación mensual
PROPIA	50	4.5	5.0%	±	4.9500	1.5248		✔
DTU	50	3.5	80.0%	±0.35	3.8341	1.4665		
MERRA-2	50	4.1	50.0%	±0.57	4.9500	1.5248	✔	✔
VAISALA	80	5.3	45.0%	±		2.0000		
CENER	30	1.9	40.0%	±0.00	2.0290	1.2627		
Result	**50**	**3.68**	**--**	**±0.35**	**4.1301**	**1.5248**		

Esta tabla muestra las diferentes fuentes de datos en el cual calculamos la velocidad media de la zona para así poder generar el estudio de producción eólico, de cada fuente de datos se obtienen unos valores que luego para el cálculo de las medias, se aplican según el grado de confianza de los mismos.

Datos de Generación Eólica:



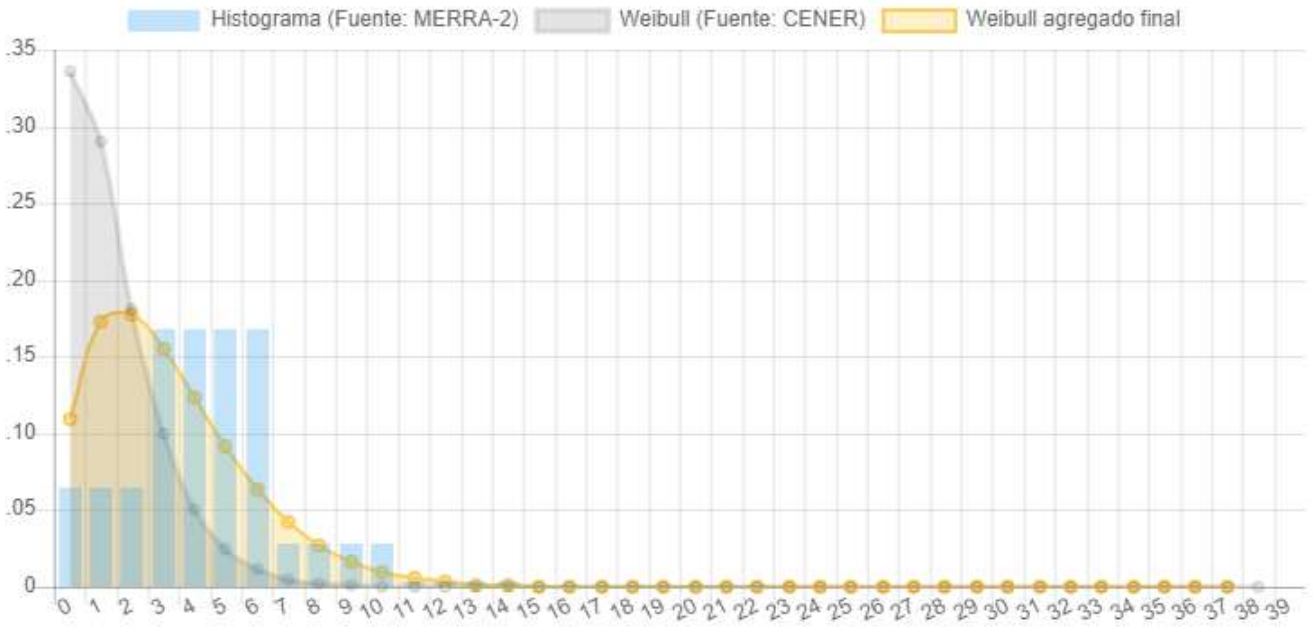
Enair 200



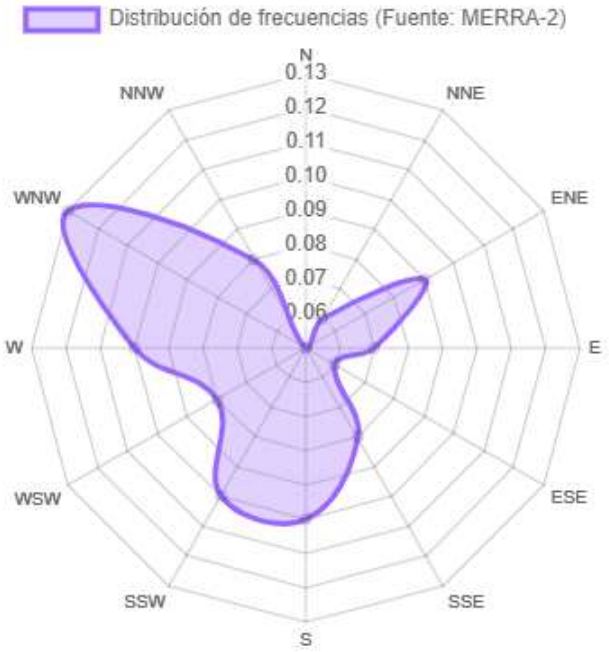
Producción eólica en kWh

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	D
Wind speed (m/s)	3.6	3.7	3.6	3.4	2.7	2.6	2.8	2.7	2.6	3.0	3.4	
kWh/day	54.8	59.1	53.9	46.2	25.0	20.8	25.4	24.0	22.0	32.3	48.3	5
kWh/month	1699	1671	1669	1387	775	625	787	746	661	1002	1449	17

Información Eólica:



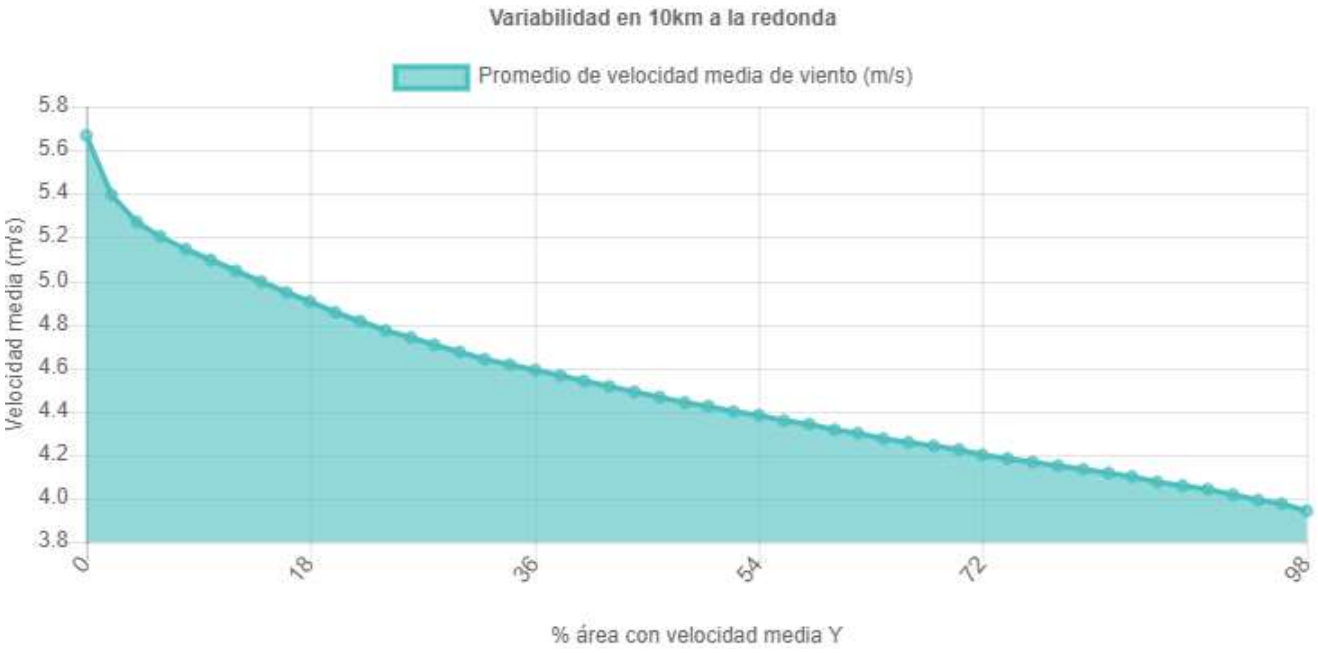
Histograma de los valores de velocidad de viento en m/s más constantes de la zona, mostrando por cada velocidad de viento los valores Weibull y las medias de Weibull. Representación gráfica de cómo se reparte el historial de vientos.



La **rosa de los vientos** permite conocer los vientos predominantes, es necesaria conocerla para instalar los equipos manteniendo libre de obstáculos el sector predominante de vientos.

La variación estacional se basa en el conjunto de datos de los últimos 30 años que MERRA-2 ha obtenido, en ella se calcula la velocidad media de viento de cada mes, se promedia y se muestra una variación respecto a la media anual en valores de %.

Los puntos mínimos y máximos corresponden al máximo y mínimo de velocidad media por cada mes de esos 30 años, mostrando un 66% de ese valor (estamos hablando aproximadamente de una desviación estándar).



La variación espacial muestra los valores promedios de velocidad de media de viento de los modelos sobre un cuadro como mínimo de 1km^2 (para DTU y de 25km^2 para CENER o VAISALA...) ofreciendo la variación que se puede encontrar en el territorio alrededor del punto elegido.

Suponemos que se cogen todas las medidas hechas en el territorio de los alrededores (10km^2), los ordenamos de mayor a menor respecto a la velocidad media y sacamos los promedios de viento. De esta forma en el 100% encontramos la velocidad media del territorio, pero conforme disminuye el % se va incrementando el viento dentro del cuadro seleccionado, de forma que por ejemplo el 1% corresponderá al 1% de más viento de ese punto.

Annex H

Grid-Connected System: Simulation parameters

Project : **TFG**

Geographical Site	**Barcelona**		Country	**Spain**
Situation	Latitude	41.42° N	Longitude	2.13° E
Time defined as	Legal Time	Time zone UT+1	Altitude	273 m
	Albedo	0.20		
Meteo data:	**Barcelona**	Meteonorm 7.1 (1996-2010), Sat=74% - Synthetic		

Simulation variant : **New simulation variant**

Simulation date 09/04/19 13h02

Simulation parameters	System type	**No 3D scene defined**		
Collector Plane Orientation	Tilt	40°	Azimuth	0°
Models used	Transposition	Perez	Diffuse	Perez, Meteonorm
Horizon	Free Horizon			
Near Shadings	No Shadings			

PV Array Characteristics

PV module	Si-poly	Model	**AS-P603-250**		
Original PVsyst database		Manufacturer	AEG		
Number of PV modules		In series	9 modules	In parallel	4 strings
Total number of PV modules		Nb. modules	36	Unit Nom. Power	250 Wp
Array global power		Nominal (STC)	**9.00 kWp**	At operating cond.	8.09 kWp (50°C)
Array operating characteristics (50°C)		U mpp	244 V	I mpp	33 A
Total area		Module area	**58.6 m²**		

Inverter		Model	**UNO-DM-2.0-TL-PLUS**		
Original PVsyst database		Manufacturer	ABB		
Characteristics		Operating Voltage	90-580 V	Unit Nom. Power	2.00 kWac
Inverter pack		Nb. of inverters	4 units	Total Power	8.0 kWac
				Pnom ratio	1.13

PV Array loss factors

Thermal Loss factor	Uc (const)	20.0 W/m²K	Uv (wind)	0.0 W/m²K / m/s
Wiring Ohmic Loss	Global array res.	123 mOhm	Loss Fraction	1.5 % at STC
Module Quality Loss			Loss Fraction	-0.5 %
Module Mismatch Losses			Loss Fraction	1.0 % at MPP
Strings Mismatch loss			Loss Fraction	0.10 %

Incidence effect (IAM): Fresnel smooth glass, n = 1.526

0°	30°	50°	60°	70°	75°	80°	85°	90°
1.000	0.998	0.981	0.948	0.862	0.776	0.636	0.403	0.000

User's needs : Unlimited load (grid)

Grid-Connected System: Main results

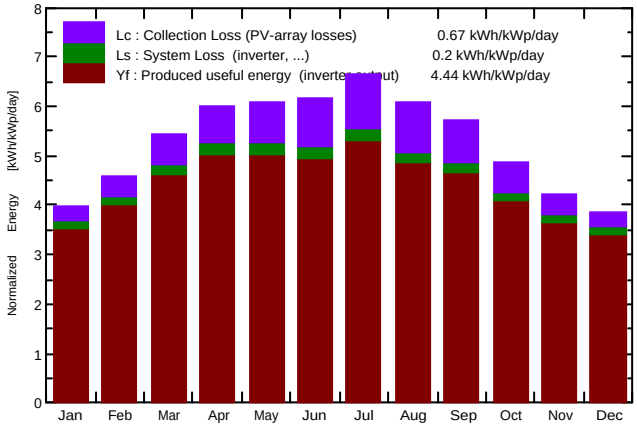
Project : **TFG**

Simulation variant : **New simulation variant**

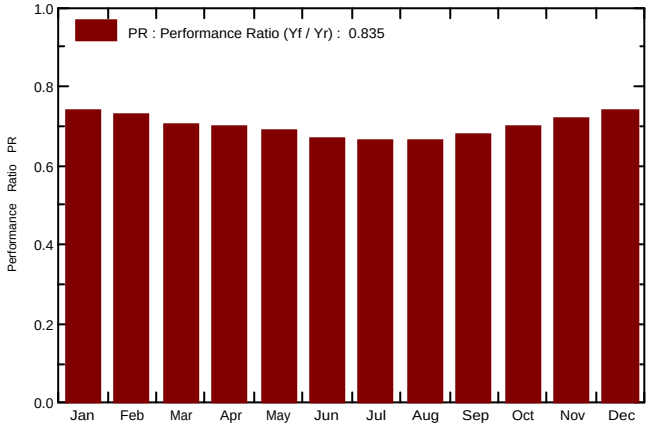
Main system parameters		System type	**Grid-Connected**		
PV Field Orientation		tilt	40°	azimuth	0°
PV modules		Model	AS-P603-250	Pnom	250 Wp
PV Array		Nb. of modules	36	Pnom total	**9.00 kWp**
Inverter		Model	UNO-DM-2.0-TL-PLUS	Pnom	2000 W ac
Inverter pack		Nb. of units	4.0	Pnom total	**8.00 kW ac**
User's needs		Unlimited load (grid)			

Main simulation results					
System Production		**Produced Energy**	**14.57 MWh/year**	Specific prod.	1619 kWh/kWp/year
		Performance Ratio PR	83.49 %		
Investment		Global incl. taxes	12647 €	Specific	1.41 €/Wp
Yearly cost		Annuities (Loan 5.0%, 20 years)	1015 €/yr	Running Costs	0 €/yr
Energy cost			**0.07 €/kWh**		

Normalized productions (per installed kWp): Nominal power 9.00 kWp



Performance Ratio PR



New simulation variant

Balances and main results

	GlobHor kWh/m²	**DiffHor** kWh/m²	**T Amb** °C	**GlobInc** kWh/m²	**GlobEff** kWh/m²	**EArray** MWh	**E_Grid** MWh	**PR**
January	67.4	26.23	8.01	123.9	121.5	1.033	0.990	0.888
February	82.4	33.52	9.15	128.3	125.4	1.058	1.013	0.877
March	131.1	45.81	11.95	168.9	164.7	1.348	1.288	0.847
April	166.5	64.52	14.15	180.1	174.3	1.423	1.360	0.839
May	198.9	76.98	17.92	188.9	181.9	1.469	1.402	0.825
June	205.5	71.88	22.11	185.2	178.3	1.407	1.342	0.805
July	222.4	74.03	24.47	206.3	198.7	1.551	1.481	0.798
August	183.0	67.99	24.54	188.4	182.3	1.418	1.354	0.798
September	142.2	49.63	20.70	172.1	167.3	1.319	1.260	0.814
October	105.2	43.63	17.52	151.1	147.5	1.192	1.141	0.839
November	71.6	25.97	11.90	126.7	124.2	1.030	0.987	0.865
December	59.5	22.19	8.51	119.3	117.0	0.994	0.954	0.889
Year	1635.7	602.37	15.95	1939.3	1883.0	15.242	14.573	0.835

Legends:

GlobHor	Horizontal global irradiation	GlobEff	Effective Global, corr. for IAM and shadings
DiffHor	Horizontal diffuse irradiation	EArray	Effective energy at the output of the array
T Amb	Ambient Temperature	E_Grid	Energy injected into grid
GlobInc	Global incident in coll. plane	PR	Performance Ratio

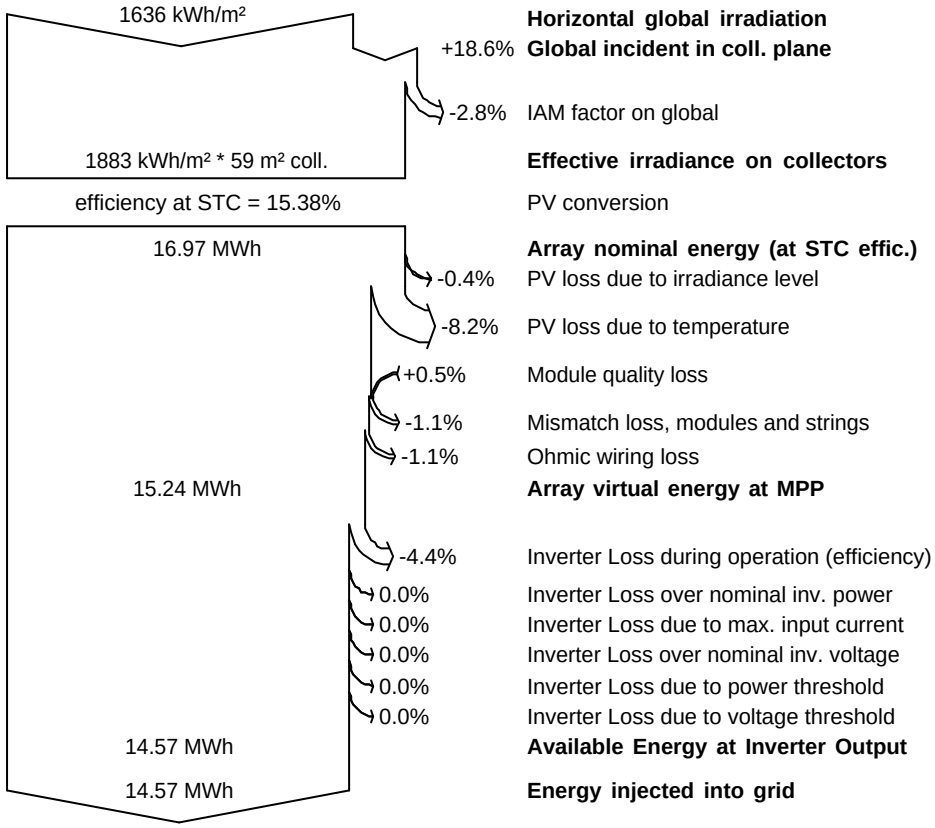
Grid-Connected System: Loss diagram

Project : **TFG**

Simulation variant : **New simulation variant**

Main system parameters	System type	**Grid-Connected**		
PV Field Orientation	tilt	40°	azimuth	0°
PV modules	Model	AS-P603-250	Pnom	250 Wp
PV Array	Nb. of modules	36	Pnom total	**9.00 kWp**
Inverter	Model	UNO-DM-2.0-TL-PLUS	Pnom	2000 W ac
Inverter pack	Nb. of units	4.0	Pnom total	**8.00 kW ac**
User's needs	Unlimited load (grid)			

Loss diagram over the whole year



Grid-Connected System: Economic evaluation

Project : **TFG**

Simulation variant : **New simulation variant**

Main system parameters	System type	**Grid-Connected**		
PV Field Orientation	tilt	40°	azimuth	0°
PV modules	Model	AS-P603-250	Pnom	250 Wp
PV Array	Nb. of modules	36	Pnom total	**9.00 kWp**
Inverter	Model	UNO-DM-2.0-TL-PLUS	Pnom	2000 W ac
Inverter pack	Nb. of units	4.0	Pnom total	**8.00 kW ac**
User's needs	Unlimited load (grid)			

Investment

PV modules (Pnom = 250 Wp)	36 units	175 € / unit	6300 €
Supports / Integration		30 € / module	1080 €
Inverters (Pnom = 2.0 kW ac)	4 units	768 € / unit	3072 €
Settings, wiring, ...			0 €
Substitution underworth			0 €
Gross investment (without taxes)			**10452 €**

Financing

Gross investment (without taxes)		10452 €
Taxes on investment (VAT)	Rate 21.0 %	2195 €
Gross investment (including VAT)		12647 €
Subsidies		0 €
Net investment (all taxes included)		**12647 €**
Annuities	(Loan 5.0 % over 20 years)	1015 €/year
Annual running costs: maintenance, insurances ...		0 €/year
Total yearly cost		**1015 €/year**

Energy cost

Produced Energy	14.6	MWh / year
Cost of produced energy	0.07	€ / kWh